

Application of Thermal Ink Jet Printing to Industrial Markets

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Abstract

Thermal Ink Jet technology is a well-known and accepted printing solution in the office and home printing market. As TIJ technology has evolved over time, new market applications have been discovered. The application of TIJ in these new markets should not be discounted, nor blindly applied. The advantages that TIJ has demonstrated in the desktop printer market can be leveraged and applied to various industrial markets. Thermal Ink Jet can offer higher levels of print quality and reliability at a lower cost than what is available in the industrial market today. This paper steps through some examples where Thermal Ink Jet has been successfully applied in industrial markets where it was not previously believed that TIJ could deliver the performance required.

Key Criteria for Thermal Ink Jet for the Industrial Printing Market

When investigating Thermal Ink Jet technology for an OEM industrial application, there are several key factors that should be considered. Many of these factors are obviously related to the technical feasibility of Thermal Ink Jet to meet the technical requirements of the industrial application. There are also other business-related aspects that need to be considered when evaluating a printing technology.

Many of the assumptions that are made about Thermal Ink Jet come from our experience with the desktop application where it is best known. There are several key aspects about Thermal Ink Jet that need to be considered when applying TIJ to industrial markets that are significantly different, and need special consideration.

Applying Thermal Ink Jet in the industrial market has different requirements than the technology was originally designed for in the desktop world. Some of these requirements require some special considerations in the selection and application of TIJ in the industrial application. There are also other aspects of Thermal Ink Jet that are required in the desktop market that do not need to be considered in most industrial applications, making it easier to use in those applications. As an example of how Thermal Ink Jet has been implemented in the industrial marketplace, we can evaluate a particular implementation for discussion here. This paper will look at the selection of TIJ in the industrial envelope printing application. There are several envelope-printing mechanisms in the market today that use Thermal Ink Jet. In looking at one as an example here, we can see how the technology selection process was applied to Thermal Ink Jet.

Variety of Options

The number of Thermal Ink Jet product options available to match the application is an important area of consideration, not only for a good technical match to the application, but also for other business reasons. Not all industrial printing applications are the same, and the needs for these applications will evolve over time. The ability to change with the technical and business needs, and evolve as these needs change over time is an important item to consider. In the desktop market, a printer has a defined use, and if it becomes obsolete, the entire unit is usually replaced with a more advanced model. This can be easily done because of the relative low cost of the entire unit. Industrial applications often are composites of several technologies in one final assembly. The ability to modify and upgrade each part of that assembly is important in making sure that the investment in the equipment can keep up with the changing needs of the market. When considering a printing technology, it is important to have a selection of different printheads. The ability to upgrade or downgrade the technology as things change can be a significant advantage in adapting an application as the market requires.

The envelope printing market has a range of different requirements inside of that market. There are desktop stand-alone printers, and high speed integrated systems. As a manufacturer of envelope printing equipment, you would want to have a variety of printhead technologies to choose from for each market segment. On the very low end, where you may want to print single envelopes at a time in batch mode, a low-end printhead that can scan across the envelope will be adequate for these needs. One example of this on the market today is the Bryce models 5K and 7K envelope printers. In these examples, the selection of the HP 51626A printhead was ideal. This is a low cost, 300-dpi printhead with 50 nozzles. This printhead was simple to integrate into the machines, and it offers a high quality image for a low price. There is another desktop envelope printer that is a higher end model with the Rena DA-610 envelope printer. This model utilizes the HP 51645A printhead, which prints at 600 dpi with 300 nozzles. This is a higher speed, higher quality solution for the same market, but it offers a different

range of capabilities and quality. The 600-dpi printhead was more complex to implement into the machine than the basic 300-dpi printhead, but it offers things that the 300-dpi printhead cannot offer. It has a 1/2" print width, so it can print at 3 times the speed as the 1/6" print width of the 300 dpi printhead when used in the same scanning axis mode. The 600-dpi printhead also gives a higher print quality level than the 300-dpi printhead. This may or may not be needed for the particular application used here, and it is a judgement call based upon the market needs.

For an even higher end envelope printer, the AstroJet III envelope printer has the same 1/2" wide 600 dpi printheads in a fixed array over a moving belt, and the envelopes pass underneath the printhead array on the transport belt. This enables much faster speeds because the array of printheads can print the envelope in a single pass, as opposed to having to make several passes to print the required information. In this example, eight 600-dpi printheads were placed in an array across the page, enabling a 4" tall address section that can be printed in a single pass.

Another important aspect to consider is if the different printheads are currently available on the market today, or if they need to be developed for the required application. Without several options to choose from, a non-optimal solution may be forced into the application. It is a very common practice to install an over designed printing system with the thought that the business will grow into the capability over time. Instead, many times the business needs change significantly all together, or the growth is slower than anticipated, leaving an overpriced, and over designed printing solution. Fitting the printing technology to the business need is an important step in building a successful combination. Having a portfolio of printheads that are basically the same in performance does not give the best selection of options for the application needs. The range of capabilities should be wide enough to differentiate the capabilities of the printheads.

Custom Printheads:

If a standard printhead does not fit the application needs, it is important that the TIJ technology supplier be able to develop a custom solution to fit the application needs. An important aspect of custom printheads to consider is how much the custom solution varies from the standard product. If a custom printhead is significantly different from the standard printhead that is offered on the market today, then the performance characteristics of that new printhead will be much less understood, and much more costly to develop and support in the long term. This is another reason why it is important to have a wide selection of printheads already established on the market to choose from that cover a wide range of capabilities. If a wide range of printheads is available, it will be more likely that a custom printhead can be developed that will suit the needs of the industrial application, and still be technically similar to an existing printhead that is currently on the market. Making small leaps in printhead technology to suit a custom need can insure a high chance of success. Making a large leap to develop a new printhead capability adds significant risk and has hidden costs associated with it, not to mention long-term support issues after it is developed.

In the envelope printing market, there have been products developed specifically for this market, and it's particular needs. The postage metering segment of the envelope printing market has a particular need for red inks that can be used for printing the postal meter indicia. There are actually two different red postage meter inks required. The US, along with most of the rest of the world's postal agencies requires that the red ink be fluorescent. They require a certain level of fluorescence so that the envelopes can be automatically faced in the automated equipment at the post office to know if there is evidence of postage on the envelope. In Germany and in the UK however, the red ink is required to be non-fluorescent. Special postage meter inks were developed for the meter application market to meet these needs. There is red fluorescent ink, and red non-fluorescent ink available to be used in the appropriate market segment. The inks were developed to operate in the same standard cartridge as the current black ink that is on the market today. As a result, the meters that use these cartridges have the flexibility to print with either the red, red fluorescent or the black ink without any modifications to the hardware, only a new print cartridge is required.

Flexibility:

The production floor environment requires a level of flexibility that enables equipment to be utilized for a variety of applications. One of the advantages that Thermal Ink Jet technology has over other imaging technologies is the capability to change ink systems very quickly and easily. This is made possible by the fact that Thermal Ink Jet technology is self-contained. The ink supply and the printhead are integrated into a single unit. This single unit can be quickly replaced to enable different ink colors or ink chemistry for different applications. The above example of the postal meter inks is one case where this can add flexibility to a hardware design based around Thermal Ink Jet. Unlike other ink jet technologies, changing a Thermal Ink Jet print cartridge does not require any flushing of ink reservoirs, or cleaning of the printhead. Another application for this type of flexibility is demonstrated the existing DesignJet 2500CP large format printer. These printers can switch from dye based ink set to a pigmented based ink set for indoor or outdoor prints. This change can be made in a matter of minutes, simply by changing the ink cartridge. No hardware changes are required. In the envelope printing market example, the flexibility to print in multiple colors with the same equipment has already been demonstrated in the postage-metering segment. This applies to the address-printing segment as well. Different colored inks can be used in addition to the black ink to generate color graphics on the envelope, logos, advertising or any other message or picture that the user wants to add color to their mail piece. The differentiating factor that Thermal Ink Jet has in this application is that the same print mechanism can be used regardless of what color is required. A different color

cartridge is simply placed in the appropriate print cartridge stall location, and the same hardware can produce a different solution for the customer.

Speed:

The printing speed that can be attained with Thermal Ink Jet technology can be well matched to fit different industrial printing applications. The various TIJ printhead options that are available on the market today are very modular in nature, which enables various levels of printing speeds. Low end industrial applications that have low print speed requirements can take advantage of the low cost printhead technologies, and not be forced to use a high end printing solution for these low end applications. The very simplest application in TIJ will print 1/8" high swaths of text or graphics at 96dpi at speeds up to 13 inches per second. This low-end application can match up very well with simple printing requirements that need variable digital data to be printed. Examples of this may be simple barcodes, lines of text or lot numbering or expiration dates on products. Higher speed applications can use either a single printhead or a stacked group of printheads to increase either printing speed or printing width. Higher speed applications can use a single printhead that is 1/2" or 7/8" wide, printing at 600 dpi. In 600 x 600 dpi print mode, this can enable line speeds of 20 - 25 inches per second. Printing at a lower resolution in the paper path axis can increase the applied line speed. By printing at 600 x 300 dpi for example, this can double the printing speed to 40 - 50 inches per second.

In the envelope printing example. Speed can be achieved in several different ways. We have already discussed using the same printhead in either a scanning cartridge mode, like is used in a desktop printer, or in a fixed head array for higher speed applications. The AstroJet III envelope printer uses a Thermal Ink Jet solution, and it can print a 4" wide swath up to 50 ips with an array or eight printheads in parallel.

To achieve higher printing line speeds, it is technically possible to place multiple printheads in series, and the timing for each printhead can be adjusted to interlace dots between the printheads. By doing this, 2 printheads can be used to print at 80 - 100 inches per second, 3 printheads can be used to print at 120 - 150 inches per second and so forth. This has not been implemented in the market to date, but the technology exists to deliver this solution. Future printheads will have more nozzles, and will fire at higher frequencies, enabling higher printing speeds.

There are potential limitations that future multiple printhead configurations may have. One of the potential limitations may be the inconsistency of the paper path speed that can create dot placement errors. Another potential limitation could be with the capability of the electronics to manage the data stream with this many dots being printed at high speed. For example, a two-pen in-line configuration printing 7/8" wide at 600 x 300 dpi at 100 inches per second has a data stream of 15.72 million dots per second. This will be a challenge for the future to enable electronic circuits to handle the data stream to enable very high density of information flow.

Print Quality:

One of the largest advantages that Thermal Ink Jet can offer the industrial market today is in the area of print quality. Most current ink jet applications in the industrial market use piezo or continuous ink jet solutions that print at 100 - 200 dpi. Thermal Ink Jet can deliver significantly higher print resolution at a very low cost. Print resolutions of 300 or 600 dpi can be delivered by TIJ technology for a fraction of the cost of an existing ink jet solution on the market today. The evolution of smaller and smaller ink drops enables finer edge definition, and smoother gray scale transitions, which enables a higher quality of printing. The combination of very high print quality, and a very low cost is something that no other print technology on the market today can match.

Many of the envelope printing applications on the market today like the Buskro envelope printer that uses Thermal Ink Jet technology are replacing similar units that were using continuous ink jet technology that print at 100 or 150 dpi. The print quality improvement that the envelope printing market has seen by the migration to Thermal Ink Jet has been significant.

Cost:

Thermal Ink Jet technology offers a cost advantage for several industrial printing applications. Because of the fact that the printhead technology is leveraged from the high volume desktop market, a very high volume manufacturing operation is possible. There are other inherent cost advantages that go along with the manufacturing processes used in Thermal Ink Jet. The Thermal Ink Jet technology uses electrical circuit manufacturing processes, which offers a very reliable and precise operation at a low overall cost. The multiplexed addressing and the integrated electronics that is used in the TIJ printhead allows for a much simpler electrical connection scheme than other imaging technologies. This enables the printing system to achieve higher throughput and higher resolution without increased system cost and size. The cost of some typical ink jet printing options currently used in the industrial printing market today range from $30K - $100K each for the hardware alone. If the service and maintenance costs, and the on-going consumables costs are factored into the equation, the actual operating costs for the industrial printing market are much higher.

A typical Thermal Ink Jet solution for envelope printing in the market today costs about $5K - $10K for the hardware, and it has virtually no maintenance costs associated with it since the printhead is replaced automatically with each ink reservoir change, giving the user a new printhead every time. This renewable print engine concept has proven to be very effective in the desktop applications. The end user automatically gets a new printhead with each cartridge replacement. Not only does this insure that the user has fewer printhead related service

issues, but it also guarantees that any printhead or ink improvements made in the printhead manufacturing process or in the materials over time are automatically realized by the user, without any upgrade to the printing hardware.

Reliability:

A key aspect about the reliability of Thermal Ink Jet is based upon the fact that there are no moving parts in the system other than the ink itself. This is one factor that makes TIJ so reliable over time and from one print cartridge to another print cartridge. The printhead manufacturing process and materials have been constantly refined and improved since TIJ was first brought to market in 1984. The fact that the user gets a new printhead every time they replace the ink cartridge insures that their printing solution returns to the as new condition with every changeover.

In an industrial printing application, reliability means more that just the materials and the printing hardware. The system also needs to have low downtime during change-overs, cleaning, replacement, servicing and operator intervention. Thermal Ink Jet technology is self-contained and modular. This leads to very low operator instructions required to operate and maintain the printheads. The desktop printer market has demonstrated the capability for non-educated operators to successfully replace, maintain and care for Thermal Ink Jet printheads. In the industrial printing market, this can have advantages of operator training required to maintain the printing technology, and the reliability of having the system operating at a high level of system readiness for low investment.

A distinct difference in Thermal Ink Jet printing in the envelope printing market versus the desktop market is in the area of servicing the printheads. The envelope printing market allows for different printhead servicing methods than would be allowed in the desktop market. There are many envelope-printing applications in the market today that do not service the printheads at all. With the Prism JETMAIL envelope printer for example, the operators simply wipe the heads with a clean wet cloth before they start operating, and they begin printing. This is an example where the requirements for an industrial market can be significantly different than for a desktop market. The desktop market would not tolerate this kind of a servicing algorithm; it requires more of a manufacturing environment than a desktop environment. A self contained, automatic printhead-servicing algorithm is incorporated in each printer in the desktop world to manage the servicing of the printheads. The ability to eliminate the automated servicing requirements from some of the envelope printing devices makes it even simpler to build, and enables a lower overall hardware cost.

Conclusion

In the industrial market, Thermal Ink Jet technology has successfully been implemented in a wide variety of applications. The specific examples of envelope printing solutions shown here are representations of how TIJ can be applied in an industrial application. There are other existing applications that were not discussed here that have similar requirements, and can have similar application solutions. The cost benefits that are realized by levering the high volume manufacturing associated with the desktop printer market give Thermal Ink Jet a distinct advantage over other digital imaging technologies. The low overall systems cost that TIJ can provide combined with the high reliability and ease of use that is associated with TIJ gives a unique combination in the printing industry. Industrial printing will open up new applications that have not been tapped before.