# Industrial Applications of Thermal Transfer Printing

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## Introduction

Thermal Transfer is a digital printing methodology used in a variety of commercial and industrial printing applications. Some applications of thermal transfer, such as color office printing, have been displaced by other digital printing methods such as inkjet and color electrophotography. However, thermal transfer remains the dominate printing technology in other areas such as auto-identification, barcode, flexible packaging, tag and label printing. The reasons for this dominance will be discussed and include printing speed, printer reliability, broad receiver latitude, high image durability and low ribbon cost. Unlike other digital imaging methodologies, thermal transfer printing supplies are competitively produced by a number of different manufacturers. This has fostered a great deal variety of consumable offerings and very low pricing.

## Discussion

Color office printing has undergone a rapid technology substitution from thermal transfer to inkjet over the last 5 years. The chief advantage of inkjet printing is that there is very little waste of colorant, compared to thermal transfer printing. If you are only printing on 10% of the page, then you only use a proportional amount of ink. In contrast, thermal transfer printing typically requires a 1:1 area ratio between the ribbon and the substrate. Thus, if you are only printing on 10% of the page, 90% of the ribbon is wasted. This was exacerbated in color thermal transfer printing where 3 or 4 color panels were required to print a full color page. This tremendous waste of ribbon, perhaps up to 360%, made color thermal transfer an attractive target for substitution by inkjet. In addition, color thermal transfer also required each color to be printed separately, making the process very slow. Inkjet printing in contrast can use separate printheads to print all the process colors simultaneously.

Inkjet printing has yet to have any significant penetration into monochrome tag, ticket, barcode and label printing. While the ink is inexpensive to manufacture, it supports a high level of profit. Because the OEM's typically hold the intellectual property on the ink and the printers, they are able to virtually eliminate after market competition on the inks. They use the annuity stream on the inks to sell the printers at very low prices. Competition in the thermal transfer ribbon business has driven down end use pricing significantly over the last 5 years. Customers can now choose from a variety of ribbon types supplied from several different manufacturers. This allows them to trade off ribbon performance with ribbon cost.

Inkjet printing typically requires about 11cc of ink to completely cover 1 square meter. At a cost of $500 per liter for ink, an end user would spend $5.50 to completely cover a 1 meter square print with a single color. A typical thermal transfer ribbon would cost about $.16 per square meter. Thus, one can see the advantage of using thermal transfer. Typically tags, shipping labels and bar codes are printed between 10 and 25% coverage. This would reduce the inkjet cost to $.55 to $1.32 per square meter, still more than the $.16 they would spend on a thermal transfer ribbon.

Thermal transfer printers use parallel printing (printing one line at a time) and commonly operate in the range of 15 cm/sec to 30 cm/sec. Some TT printers for the flexible packaging market can print at 56 cm/sec. In comparison, inkjet printers use serial printing and have to scan the printhead back and forth across the page. These printers can only add printing speed by increasing the number of printheads. This can greatly increase the cost of the printer. Typical office type inkjet printers operate at speeds of 3.8 cm/sec.

Thermal transfer printers are highly reliable. They are designed to operate in a wide range of environments (Shipping Docks, Factory Floors, Offices and Homes). These printers have very few moving parts as they are parallel printers, printing one line of information at a time. The linear thermal printheads are very durable as well, often printing 50 km or more of substrate before replacements are necessary. Another reason for the high reliability of these printers is the separation of function built into the ribbons. The backcoating on the ribbons controls the printhead-ribbon interface. Such backcoats are designed to lubricate the printhead over the wide printing temperature range (100º - 400ºC), providing a coefficient of friction which is relatively independent of temperature. The face side of the ribbon contains the ink coatings, providing the desired printing characteristics (speed, durability, color, etc.). In contrast, inkjet inks must combine both functions. This greatly restricts ink formulation latitude and reduces the overall reliability of inkjet printheads. For example, it has not been possible to formulate white inkjet inks because the physical nature of the Ti02 pigments required for these inks tends to rapidly clog the inkjet printhead nozzle. Because the white pigments are on the imaging side of a thermal transfer ribbon, no such head media interface problems exist. A number of white thermal transfer ribbons have been on the market for some time. While a variety of means have been established to deal with such issues, the overall reliability of inkjet printing is still lower than that of thermal transfer.

Thermal transfer printers can print onto a wide variety of paper and synthetic substrates. These substrates need not be coated to achieve good printing performance. In contrast, inkjet printers require expensive coated papers to achieve high quality barcode printing. There is a very limited selection of tag stocks for IJ printing. Synthetic supports must be coated with an expensive ink receptive layer if aqueous inks are to be used. Solvent based inks can be used on synthetic substrates, but these inks pose an indoor air pollution risk because of their high VOC content. Nearly any flat substrate, including PTFE (polytetrafluoroethylene), can be printing on, using thermal transfer printing. The fact that increasing temperature lowers the surface tension of a liquid is primarily responsible for this great capability. Thermal transfer inks are melted or softened by the head of the thermal printhead. The print energy is typically optimized for a given ink/substrate pair. In general, the thermal transfer temperature is raised high enough so that the imaged ink fully wets the substrate. Once cooled, the ink solidifies, adheres to the substrate and releases from the ribbon.

There are a large variety of ribbon types for thermal transfer printing. These ribbons range from simple general purpose wax ribbons for label printing to high performance resin types for printing outdoor signage. In contrast, most inkjet printers are optimized for only one type of ink. This restricts the use to a much more limited set of applications for an inkjet printer compared to a thermal transfer printer. In general, thermal transfer printing provides exceptional print durability on a wide variety of substrates. General purpose, wax based thermal transfer ribbons are generally used for printing shipping labels, bar codes, tickets and tags. These images are often subjected to environmental (rain, heat, humidity, etc.), mechanical (smudging, scratching, etc.) and chemical (fingerprints, cleaning agents, etc.) stresses in their normal use. These images, printed on inexpensive natural and synthetic substrates, show exceptional durability to these stresses. Such image durability has been difficult to duplicate with other digital printing technologies at comparable costs/image. In contrast, the durability of thermal transfer ribbons may be further enhanced by incorporating compatible resins into the ink formulations. These so called premium ribbons have higher levels of scratch, smudge and chemical resistance needed for more demanding applications.

Thermal transfer ribbons may be formulated for demanding applications like outdoor signage. Such ribbons are typically formulated from UV resistant high polymer resins and organic pigments. Images printed onto typical outdoor substrates line PVC (polyvinylchloride) are extremely fade resistant and don't require expensive over-lamination. Since the colorants are not water soluble or pH sensitive, they are retained in the resin binder during their outdoor service. The particle size of these pigments is extremely small, allowing for outstanding subtractive color gamut. After the equivalent of 1 years outdoor exposure in southern Florida, in an Atlas Weatherometer, the subtractive primaries color change for such thermal transfer images on PVC is in the range of 2 to 15 delta E.

Thermal transfer is also branching out into areas where its attributes provide a competitive advantage. For example, while numerous patents exist on the use of inkjet for digital printing of CD's and DVD's, thermal transfer printing has been much more successfully applied. Several printers from Rimage and Primera have been designed to digitally print directly on CD's and DVD's with thermal transfer printing. The use of resin based inks in this application yields images which are highly durable. These ribbons are able to print onto a wide variety of discs manufactured by this industry. In contrast, direct inkjet printing of CD's is restricted to discs which are specially coated with ink receiver layers. Even so, such inkjet printed CD's are easily damaged if exposed to any amount of water, for example a damp finger.

Thermal transfer is used to digitally print variable information directly on apparel labels. Examples of such printing include apparel care instructions, size, lot, vendor and other relevant information. Typically, substrates included smooth woven polyester, dip coated nylon and polyurethane. Specially formulated resin thermal transfer inks adhere well to these coated and uncoated fabrics giving good wash fastness and steam resistance. New thermal transfer technology has been disclosed which can be printed directly onto cotton and other fabrics with similar levels of durability. While inkjet has also been widely used in the area of fabric printing, typically this is done indirectly, utilizing a transfer sheet.

In the future, thermal transfer printing will be extended to more challenging applications, substituting for analog printing technologies like silk-screen printing. The digital capability of thermal transfer will make short runs cost effective in a diverse range of analog printing applications. In particular, the printing of glass and ceramic articles is in need of such innovations. Trends toward the mass customization of such articles demand digital solutions. However, the inorganic pigments and crushed glass fluxes required in such printing applications are unlikely to be compatible with inkjet printheads. In contrast, such materials are quite amenable to incorporation in thermal transfer inks.

## Conclusion

Thermal transfer printing has a variety of strengths and weaknesses. While it is not well suited to color office printing, it continues to dominate applied digital printing applications like auto-identification (bar code printing), shipping labels, tags and tickets. This versatile technology has advantages in speed, substrate and ink latitude and reliability over inkjet printing. Because of the separation of functions on a thermal transfer ribbon, difficult to jet pigments are easily printed using thermal transfer. These attributes will enable thermal transfer printing to continue to grow and serve a wide variety of commercial and industrial digital printing applications.