Color Pigmented Ink Jet Inks: New Developments and New Applications

Ray A. Work, III
DuPont Ink Jet Inks
Wilmington, Delaware, USA

Abstract

Since their introduction in 1996, color pigmented ink jet inks used in wide format applications have been applied to some of the most demanding applications with which ink jet has ever been challenged. Today, with higher resolution and specially designed substrates, color pigmented ink jet inks are being used in original art and art reproduction. New developments in color pigmented ink and printer technology will allow the even wider application of ink jet printing technology. In this paper these developments and their potential impact will be discussed.

Introduction

In 1996 color pigmented ink jet inks were introduced by Encad for their wide format NovaJet family of printers. Subsequently, Hewlett Packard, Mimaki, and Roland Digital, Colorspan and others have introduced color pigmented ink jet inks for new wide format, ink jet product offerings. These products required specially coated ink jet receptive media to accept these inks and to give high quality, light fast color prints. For the first time near photo quality has been achieved in a light-fast, durable, wide format product offering. Up until this time the end user faced uncertain and usually unacceptably short print light fastness for color prints from ink jet. The inks and media available gave unacceptable initial color shifts, within the first few days of printing, especially sever color change with exposure to high humidity and very poor UV fade light stability. Attempts to print fine art and fine art reproductions as well as outdoor signage proved marginal to unacceptable. Dye manufacturers were quick to work to improve this performance so that the fading that initially occurred within hours could now gave useful stability on some substrates for weeks and even months depending on the level of UV exposure and nature of the substrate. The pigmented inks provided by DuPont to our customers withstand very long periods of exposure to UV light with very little fading and more importantly, very little hue shift. A large color gamut with excellent printing reliability and print quality performance on films and papers has been achieved.

This is only the beginning. Improved ink technology providing performance more like "paint" than traditional ink jet ink is being developed. More media independence, excellent color gamut, light fastness and water fastness on a wide variety of "plain" media, i. e. media without an ink jet receptive coating without the use of penetrating oil or solvent-based inks is being demonstrated. With this technology the end user will have more freedom to chose substrates, incur lower overall cost, and achieve print performance comparable with traditional analog printing. With this technology new markets like photo finishing, commercial portrait photography and Giclee' (fine art reproduction using ink jet) and many more that require these characteristics will grow. This paper discusses these ink jet systems' characteristics and their potential impact in the ongoing conversion of analog to digital printing.

Ink Jet Printing Technologies

Today there are six forms of ink jet technologies being practiced widely:

1. Piezo drop on demand
2. Thermal drop on demand
3. Electrostatic deflection drop on demand
4. Continuous flow-Hertz
5. Continuous flow binary deflection
6. Continuous flow multi-deflection

The ones which are important for high quality, color pigmented ink jet printing are the drop on demand technologies. Hewlett Packard, Lexmark, Canon, Xerox and Olivetti provide thermal drop on demand solutions to the market. Seiko Epson themselves and through Mimaki, Mutoh and Roland Digital, Hitachi Koki, Spectra, Tektronix, Brother, Konica and Xaar bring piezo drop on demand to the market. Seiko Epson recently introduced electrostatic deflection ink jet technology to the market.

These drop on demand technologies are similar in their function. They all shoot a drop of low viscosity (2-20 centipoise) ink jet ink on demand when the ink jet printer sends an impulse to an activator at the ink chamber. This causes a droplet to be formed and propelled toward a substrate. Once formed, the ink droplet is on its own. Its properties along with those of the substrate determine the performance of the printed image. The energy used to propel a drop varies widely depending on the type of actuator used in the ejection process. Typically the thermal ink jet uses the most energy propelling the ink droplet from the orifice using a steam bubble vs the piezo or electrostatic deflection technology which uses a moving wall to send a weak pressure wave through the ink. These are very important differences in the design and thus the function of color pigmented ink jet inks.

The ink maker's ink design and its function in the printhead are inseparable. With thermal ink jet the energy of the drop ejection process is high thus tiny bubbles are a less important problem than in the very low energy piezo and electrostatic deflection technologies. The heat provided by the resister can degrade a thin layer of material adjacent to the resister when it is heated. If the byproducts of the decomposition or other chemical reaction of the ink with the heat form a layer which builds up on the resister the degraded material insulates the ink in subsequent pulsing effecting the drop formation. Thus pigmented inks with binders which are required for "paint-like" end use performance require careful design to avoid this build-up.

With piezo the heating effect is different. There is no resister but there is heat generated by the flexing of the wall of the ink chamber. As with thermal ink jet unless controlled this causes a reduction in viscosity and may cause changes in drop volume, formation and velocity. The most important problem faced by the ink developer in designing inks for piezo or electrostatic deflection is called rectified diffusion. Pulsing the printhead compresses the ink and may shift the equilibrium between nitrogen dissolved in the ink and that in very small air bubbles entrapped on surfaces in the printhead toward bubble growth. This causes the bubble to grow until it reaches a size where it absorbs the compressive energy provided by the piezo crystal. Under these circumstances a droplet of ink will not be ejected. This is a particular problem with pigmented inks since the surface of the pigment provides nucleation for air bubbles to form more readily.

Both technologies require ink which does not dry in the orifice when open to the air and if dried ink does form on the orifice plate it must resolubilized or redispersed when exposed to wet ink. This is a particular challenge since the binders that are desirable for durable printing must not provide durable coatings on the printhead or in the nozzle.

Color Pigmented Inks

Once designed and implemented in a printing system the inks must do their job. Very fine particle size, stable dispersions, functional binders, wetting agents tuned for the substrate intended to be printed upon with dot spread, bleed and film forming properties required in the specific application being addressed. The color gamut/transparency/ UV resistance/hue optimization must be made for the intended use through careful selection of pigments and both preparation of their dispersions and the final ink formulation. It provides little benefit to have a fine particle dispersion with a durable binder if the pigment particles flocculate on drying or the binder cracks as it dries. Unacceptably poor color gamut will result.

The design is complex and the optimization difficult to achieve but when it is achieved the result is dramatic. Color pigmented inks without significant binder are now available from several printer suppliers which give properties which meet many of the needs of the fine art and art reproduction markets. Color gamut that is sufficient to reproduce many original art pieces on either ink jet canvas or ink jet watercolor paper has been demonstrated. Several are include several here at the presentation of this paper for you to examine. Longevity has been achieved which exceeds 100 years in Henry Wilhelm's color fading tests[1]. Some of these inks have been in the market since as early as 1996 and have proven their reliability and dependability.

Future Developments

What's next? Today we have water based inks without binders. To achieve the acceptable performance, special coatings are needed. In the near future "paint-like" inks that carry the binder along with them will be available. These inks will not require ink jet coated substrates. The substrate will continue to be important in determining the dot spread, ink penetration and ink adhesion of the printed image but not nearly to the same extent. Thick water absorbing layers coated on ink jet substrates will no longer be required. Post printing moisture sensitivity (a serious negative feature of many ink jet media) will be avoided. Printing water based "paint-like" inks onto non-porous surfaces like vinyl, polyester or other film materials will be widespread. The end user will be able to laminate as is current practice with non-ink jet prints or use the prints without lamination. This will enable ink jet to be used for credit card printing, photo finishing on inexpensive uncoated photo paper, vinyl signage and countless other applications which use analog printing technology today. These products should begin to be available in 2000 as printer manufactures adopt this technology in new printer designs.

References

1. Web page pdf file on permanence at www.wilhelm research.com.

Biography

Dr. Ray A. Work, III is currently New Business Development Manager, DuPont Ink Jet Inks. Dr. Work received his B. S. degree in Chemistry from Auburn University, Auburn, Alabama USA in 1966 and Ph.D. degree in Chemistry from Louisiana State University in New Orleans (now the University of New Orleans), New Orleans, Louisiana USA in 1971. Following a post-doctoral research fellowship at the University of Hawaii (Manoa), Honolulu, Hawaii USA he joined DuPont's Photo Products Department Research and Development organization at the Experimental Station in Wilmington Delaware USA. Since joining DuPont in 1972, Dr. Work has held positions with DuPont in research, marketing, business development and management. Dr. Work holds 14 patents, has over 40 publications and is a frequent speaker at symposia, conferences and workshops worldwide on the subject of ink jet inks.