Media Advances in Dye Diffusion Thermal Transfer to Facilitate a Multihead Printer System

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Abstract

This paper describes the design of media for a new multihead printer system for dye diffusion thermal transfer. The media features include a dye donor that was redesigned with a new support thickness for increased efficiency and a new component load specifically designed for this system to deliver printing in the multihead configuration. In addition, a roll fed receiver was configured to give prints without paper curl in the final print. Curve shape and incubation results are discussed.

Introduction

Dye diffusion thermal transfer (D2T2) is an imaging system that has been used for over a decade. Thermal printing, using D2T2 is used in consumer, government, professional, entertainment, and commercial applications. Generally D2T2 has been used in low-volume applications because of the limited productivity resulting from the use of a single printhead.

In order to obtain a printed image, the electronic image is subjected to color separation and converted into electronic signals. These are used to produce cyan, magenta and yellow electrical signals that are transmitted to a thermal printer. To obtain a print, the dye donor element is placed face-to-face with a dye receiving sheet, which are passed together between a thermal printing head and a platen roller. The thermal head has many printing elements and is heated to produce the desired level of dye transfer. The dye is transferred from selectively heated regions of the dye donor sheet to the receiver sheet to form a pattern with a shape and intensity that corresponds to the pattern and intensity of the heat applied to the dye donor element.[1]

The printhead contains a very hot (~300°C) print element that is in intimate contact with a dye donor ribbon. The donor ribbon contains a heat resistant or slipping layer on one side and the dye layer and laminate coated on the opposite side of the support which is typically polyethylene terephthalate (PET).

The purpose of the slipping layer is to facilitate printing by providing a surface that can survive contact with the hot printhead and is also lubricious enough to allow movement across the head.

The dye side of the donor ribbon contains alternating patches of cyan dye, magenta dye, yellow dye, and laminate that are printed in succession. As the print is made, the dye receiving layer coated on paper moves through the printer, it receives the yellow dye, backs up, receives the magenta dye, backs up, receives the cyan dye, backs up, and lastly receives the protective laminate layer. The receiver is fed through the printer in sheet format. Print time for an 8 x 10 inch print is approximately 90 seconds with this method.

As the system evolves into higher volume applications, a multihead printing system is necessary to allow faster printing times.

Results and Discussion

The approach used in the design of this system was to roll feed an existing receiver format into this multihead printer system and reformulate the dye donor to achieve desired image quality. The goal of this work is to design media to fit into the multihead printer format that is compatible with the in-line multiple printheads. This allows for the creation of high quality prints in a single pass operation at a rate of 13 s per 8 x 10 inch print.

The major change in the media was the reformulation and reformatting of the dye donor from a patch coated donor material, to separate continuous dye donors, each color coated on a separate spool. In addition, a thinner support was incorporated.

Dye Donor

The dye donor consists of numerous chemicals used to effectively transfer dye and create photographic quality images. The dyes themselves are incorporated in a polymeric binder that acts as a medium for the dyes. Plasticizers are incorporated for numerous reasons, mainly to increase dye transfer efficiency. Other components are added to affect keeping, prevent unwanted transfer, and expedite release between the donor and receiver after printing, as well as other technical, often proprietary reasons.

The thicknesses of the PET support affects the efficiency of the thermal transfer of the dyes. The thicker the support, the more heat is necessary to affect the dye diffusion process. As a result, thinner supports are desirable in that they ease the transfer process. The problem is that as the support becomes thinner, it is more prone to deformities during the heat transfer printing process. These deformities cause various printing artifacts that result in prints with undesirable marks in the image area. Areas where dye is not transferred completely or not transferred at all characterize many of these marks.

Other considerations in the choice of a support thickness are the ability to manufacture and capability of transporting the web. All coating machines have tension and drying requirements that are changeable within particular limitations. In this particular application, the dye donor material must be coated as a continuous color rather than a four-patch multicolor dye donor material. There are many ways to accomplish this from coating the same solution in all stations of a multi-station coating machine, to coating continuously laying down part of the desired dye coverage in more than one station, the sum total of which will result in the desired coverage of dye.[2] Fortunately, neither of these methods were necessary. The coating process for this application is accomplished using a single coating station for the dye by making alterations to the dye donor formulations themselves, as well as changes to the drying configurations in coating. Including the slip and two tie layers, a total of four stations are utilized in coating.

In addition to an optimized support thickness, the amount of dye, binder, and other components were optimized specifically for this system. The polymeric binder is the medium from which the dye is suspended. The formulas for all the dye donor formulations were redesigned for this system using parameters such as raw stock keeping, dye diffusion, printing artifacts, energy necessary to accomplish printing with the desired dye levels, and optimized dye to binder ratios to create the final dye formulations.

Each of the three dye patches for the continuous ribbon for the multihead printer were designed separately, with optimized dye, polymeric components, solvent and coating parameters. Figures 1 through 3 are curve shape graphs comparing the red, green and blue of a neutral gray. In each of the graphs, the y-axis is Status A density and the x-axis is the density scale divided into 16 increments.

Figure 1 shows comparison data for continuous and patch coated material for the red of the neutral. One of the key desires of the multihead system was to match the density at D-max (maximum density) of the patch coated dye donor thus maintaining current picture quality. The other areas of the curve did not have to match exactly, although it would be advantageous. The data of Figure 1 suggests that the densities of the continuous donor are nearly that of the patch-coated donor with the continuous donor having slightly more density. This near match in curve shape is an excellent result considering that the continuous donor is coated on 4.5 micron support and the patch coated donor is coated on 6.0 micron support each with different dye and component levels.

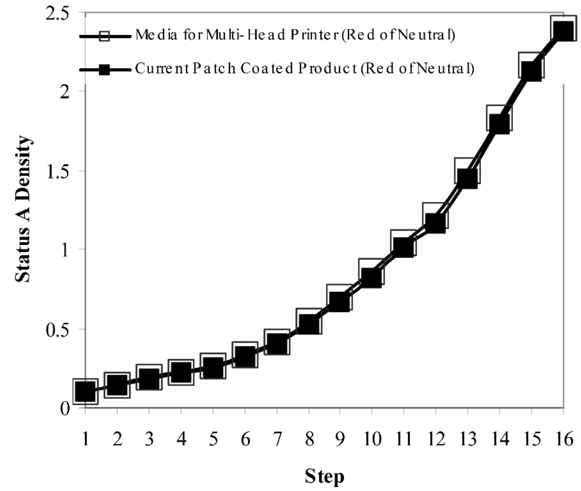

Figure 1. Curve shape comparison for red of neutral.

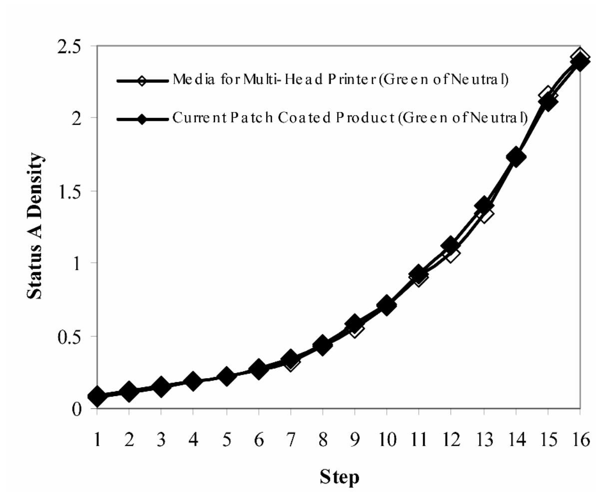

Figure 2. Curve shape comparison for green of neutral.

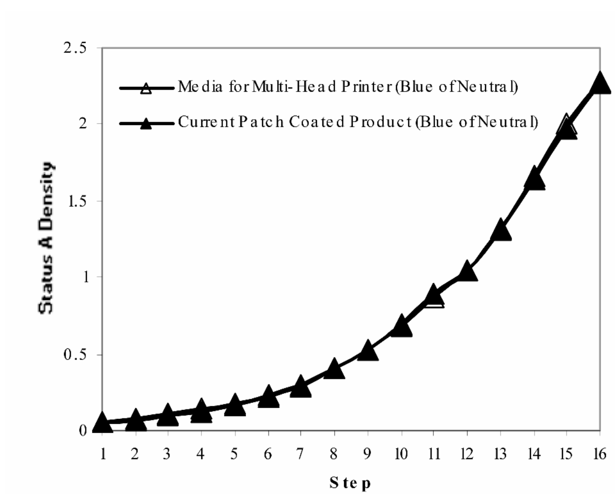

Figure 3. Curve shape comparison for blue of neutral.

Figures 2 and 3 show similar results for the green and blue of the neutral density scale. In both cases, the curve shape match is nearly identical between the patch and continuous donors. In addition, the D-max density in the green and blue are the same or slightly higher in the continuous donor when compared to the patch coated material. For these comparisons the age of the continuous and patch coated donor were identical.

Figures 4 through 6 show color balance results for the continuous versus patch donors for an incubated keeping experiment. In each graph the x-axis is the step number in an eleven step wedge where step 1 is D-max and step 11 is D-min. The y-axis is the change or delta density versus a frozen sample. In each case the incubations were done for one month at 100°F and 50% relative humidity

Color balance for red minus green density is shown in Figure 4. The goal is to have no change in the media versus the frozen sample, so it is desirable to have all the data lie on the zero line of the y-axis. Examining the results of Figure 4, the continuous media is shown to be slightly improved versus the patch coated media in this condition of temperature and humidity. Figures 5 and 6 show similar results for the red minus blue and green minus blue color balance data.

Dye Receiver

The receiver was slit and spooled into roll formats instead of the cut sheet format currently used. The major concern was the memory of the paper for core set curl. Core set curl is a phenomenon where material that is wound around a cylindrical core takes on the shape of the core. The result is that the paper has a curl after it is removed from the core, with the paper wound closest to the core having the most severe curl. Much work has been done through the years on the curl of conventional color paper. Because conventional color paper goes through a wet process and thermal printing is a completely dry process, the work done in this area with color paper was not directly transferable, and work was necessary to understand the impact with thermal receiver. This was especially critical as the paper is spooled with the dye receiver layer facing inward, toward the core, which would lead to paper curl in the undesired direction.

Unprinted paper stock with a receiving layer coated on top showed unacceptable paper curl as the paper was incubated at temperatures ranging from room temperature to 60°C (140°F). Not surprisingly, the curl becomes more exaggerated with increasing temperature. After printing, the curl of the paper was significantly different. As a result of the hot print heads, the curl that was present in unprinted samples was virtually eliminated after printing. It appears that the thermal print heads act to unexpectedly "iron" out the core set curl of the paper.

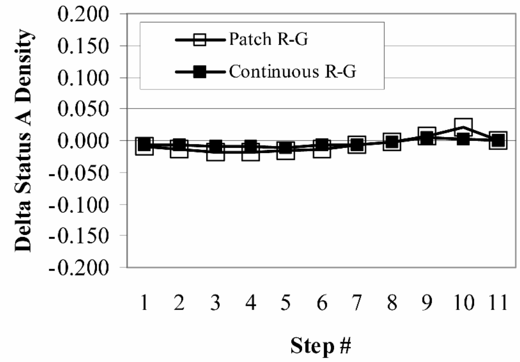

Figure 4. Color balance results for red minus green density after incubated keeping for 1 month at 100°F and 50% relative humidity.

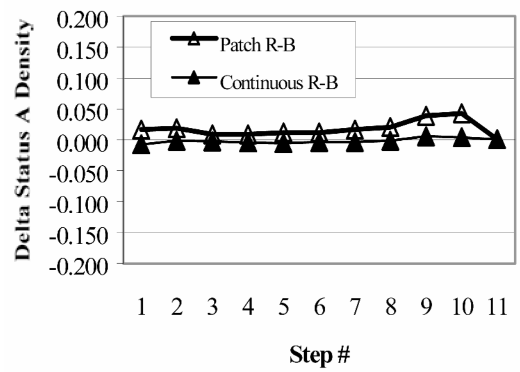

Figure 5. Color balance results for red minus blue density after incubated keeping for 1 month at 100°F and 50% relative humidity.

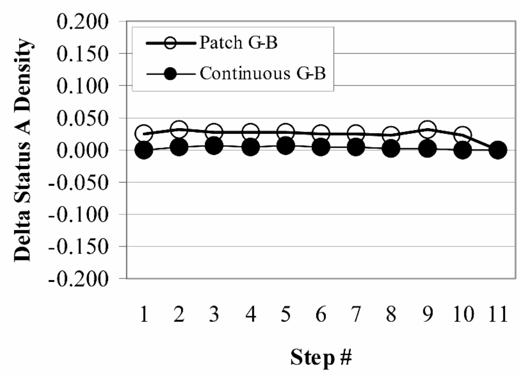

Figure 6. Color balance results for green minus blue density after incubated keeping for 1 month at 100°F and 50% relative humidity.

Conclusions

The result of this work was a dye donor formulation specifically designed for the multihead printing system to make an 8 x 10 inch print in 13 s. Incorporated into the design was a thinner support structure, optimized dye donor formulations, and a roll fed dye receiver that did not have core-set curl problems in the final print.

References

1. S. A. Brownstein, "Apparatus and Method for Controlling a Thermal Printer," U.S. Patent 4621271, November 4, 1986.
2. S. F. Kistler and P. M. Schweizer, Liquid Film Coating, Chapman & Hall, New York, 1997.

Biography

David Foster received his B.S. in Chemistry from Rochester Institute of Technology, and his Ph.D. in Chemical Engineering from the University of Rochester. He has worked at Eastman Kodak Company for 20 years, the first 17 of which were in various areas of conventional silver halide research, and for the last 3 years in thermal media research. He is a Distinguished Inventor at Eastman Kodak Company and is currently an Adjunct Professor in Chemical Engineering at the University of Rochester. He is a member of IS&T, the American Chemical Society, and the Electrochemical Society.