PRINTING COLOR IMAGES WITH TWO NON-PROCESS COLOR INKS, TONERS OR PAINTS

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Key Words: Color, Non-process

ABSTRACT:

A special modified two-color color separation method is described. These separations carry image content in the entire visible spectrum and can be used to print color reproductions using only two colors of non-process inks, toners or paints on white or colored substrates. This new method uses an non-process red ink and a second non-process ink color that may be black, blue or green. A comparison with conventional separations and other modified separations is shown.

INTRODUCTION

Our world population has become accustomed to communicating with colored graphic images. With the proper graphic images, communication can be accomplished even without words. Technological developments in scanners, imagesetters, and desktop hardware and software have made it easy to produce four-color images and print them with transparent cyan, magenta, yellow and black process inks. With proper calibration, it is possible to print process color on almost any white surface that reflects white light.

Even though it is known that color attracts readers' attention, worldwide the majority of printing is not four-color process. For example, 80% of telephone directories are printed with black and red inks.

How can printing that does not warrant, or cannot support, four-color process printing be made so that it looks like four-color process printing? To draw readers' attention, colored paper is often used for printing. But, how do you print colored images on colored paper?

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A way has been developed to print color reproductions of colored images on white or colored substrates, using two non-process colors of ink, toner or paint. A red and either black, blue or green are printed together. The reproductions appear normal and do not require process inks nor special cyan and orange inks.

MAKING SEPARATIONS

Explanation of process color

Using the normal separation process, the visible spectrum is divided into its three parts that correspond to the red, green and blue sensitivity of the human eye. A color analysis with the red, green and blue filter is done of the image. The light spectrum is split into about thirds. The image record is color corrected for the cyan, magenta and yellow ink characteristics. The tone scales are adjusted for the tone compression. Black is added in the darker neutral gray areas to increase the printable density range. Then, the separations are made and printed. If we've done our job correctly, our colors are accurate, the contrast is correct, and the grays are neutral.

If you print with only two of a normal set of separations, what happens to the other one-third of the spectrum? Where the unprinted third should have printed, there is little or no content. The resulting print is unbalanced.

What happens to the appearance of the reproduction? Without the third separation to give color balance, the two printed separations make the picture's color appear too strong. For example, if only magenta and cyan are used, the human flesh will look very purplish. A normal magenta separation prints most of the human skin detail and color. The magenta separation also adds color in the blue areas. This makes the blues less greenish. With no yellow printing, the skin appears very red.

If normal separations are printed using only the red and black separations, poor quality also results. The black separation usually prints heavy in dark shadow areas. It does not carry much tone scale information in the colored areas of the reproduction or in the highlight areas.

Early attempts by others

Early attempts to print two-color reproductions usually were printed with an orange and a cyan colored ink. The separations were made with corresponding orange and cyan filters. The process was tedious and very unpredictable. Neither black nor red was used. Therefore, the original images had to be well chosen, or the results were not always pleasing. With no black printing, the images look washed out, and all the text is either orange or cyan.

Edwards' experiments with two non-process inks

In 1975, Wallace Edwards of Toronto, Canada began work to produce colored images on substrates using only two non-process color inks. He wanted to find a way to render the visible spectrum so that the casual observer would think the colors in the printed image represented the colors in the original scene.

Edwards tried making separations with red, green and blue separation filters. He found that printing only two process colors, such as the normal magenta process color separation with magenta ink and the black separation with black ink, did not give a good color reproduction. Human skin appeared too red, because there was no cyan and yellow to balance the magenta color.

Modified separation technique

A special technique to balance the separations to represent the three thirds of the visible spectrum with only two inks was needed. Through experimentation, Edwards developed a special split-filter technique for making the color separation. No color correction masking is used.

Most printing requires black for the text. Therefore, black was chosen as one ink color to use with the modified separation approach. The second ink color is non-process red. By printing the magenta separation with non-process red ink, it is possible to print a normal "fire engine" red.

The photographic separation is made using a red filter to make a full-scale negative. Anyone skilled in the separation process recognizes this to be a cyan separation. It is an uncorrected, unmasked separation. Next a short second image exposure is made to the same film through the blue filter. This exposure fills out the needed exposure for the tonal range. In a sense, it also "dirties up" the separation. It allows the modified cyan separation to print some content in the yellow areas of the image. It also reduces some of the color strength in the blue areas.

This modified cyan separation carries content in the entire spectrum and the full tonal range. It is however heavier in the cyan areas. This separation is usually printed with black ink—although, blue or green ink could be used. This separation will print heaviest in cyan areas and lightest in the magenta and yellow areas. Therefore, it can be used to print green ink if the original colored image was predominantly green, or to print using blue ink if the image was predominately blue. Regardless of which color is used, it will tend to balance out the strong red in human skin.

The other important separation is the red separation. It is made with the green filter, similar to the way a magenta separation is made. Because this separation will need to carry some image content in the yellow portion of the image, a short blue filter exposure is added to the separation negative. This allows some red to print in yellow areas. The blue filter exposure reduces the amount of red printing in blue areas and reduces the "purple" effect. This separation also covers the entire tonal scale. It is always printed with an non-process red ink. Since it is red rather than magenta, it compensates for the lack of yellow ink printing—yet, important red colors are still produced. This separation also adds the red content needed for the human skin.

Using Adobe Photoshop to achieve the Edwards' two color images

Edwards' photographic separation process, now called Markolor, used split-filter exposures to make the sequential exposures to record multiple images on each separation negative. With the invention of the color scanner, color scanners analyze the image through three filters simultaneously. The scanner adds or subtracts the electronic values from the three signals to achieve the same effect as a split-filter exposure on a separation negative. However, the early Itek scanner and some flat-bed scanners did use sequential red, green and blue exposures to make the separations.

This author developed a process of utilizing the channels tools in Adobe Photoshop to achieve the effect of the Edwards' separations by utilizing the same exposure strengths and percentages to make the separations as taught in the patent. This technique was later refined and simplified further through a contract with the RIT (Rochester Institute of Technology) Research Corporation. There developers produced an application with a set of two-color look-up tables that would achieve the desired effect. Even though several Edwards' modified separation methods have been described above, they all achieve the same effect of the Edwards patent utilizing the standard red, green and blue filters.

PRINTING COLOR SEPARATIONS

The red with green, blue or black inks used to print the modified separations are non-process inks appropriate for printing on any substrate. Because these inks are non-process, white paper is not needed to reflect the light to the eye and to achieve the ink color. These separations can be printed on paper or other substrates, either white or colored.

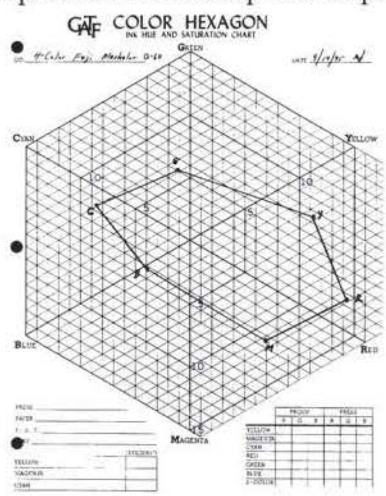
These non-process inks can be run at various densities to produce the desired image. The color balance is not as critical as it is when printing normal transparent process inks on white paper. The printer is not trying to produce an exact color match to the original colored copy. Therefore, the ink strength can be visually adjusted. Markolor separations do not appear to be dependent on specific ink densities or balances and are considered density independent.

ANALYSIS OF THE RESULTS

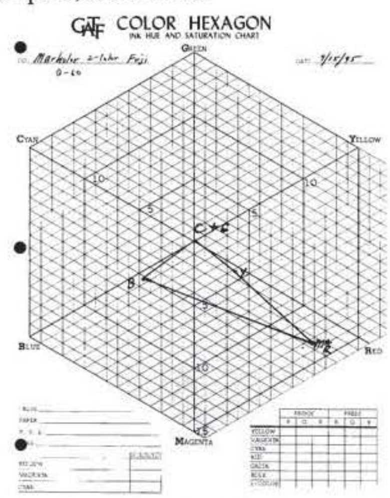
Color analysis of the printed images and the color gamuts produced by the three methods, four transparent process inks, two process inks and the Markolor non-process red with non-process blue, green or black ink was done both visually and by making densitometer measurements. Visually our eyes and brain accept the two-color reproductions. Our eyes instantly adjust to the missing colors and remap the color space in our brain. The samples printed with combinations of two non-process inks—red with green, blue or black—can be successfully printed on assorted colored papers. Also, these can be printed on any substrates such as plastic, metal and corrugated board. Visually, the results speak for themselves.

A visual comparison of the Markolor images shows us that the colors do not match those of the original or those of normal four-color separations. However, a viewer normally sees the printed image without anything to compare it with, except what is printed on the same page.

A graphical analysis of the GATF Hexagon shows the position of what would normally be the cyan, magenta, yellow, red, green and blue patches of the Kodak Q-60 test target when printed with four-color process. Note the different position of those same patches when printed with the Markolor process. One might not expect our brain to accept this warped color space, but it does.



GATF Color Hexagon of 4-color Q-60



GATF Color Hexagon of Two-color Q-60

A densitometer and the GATF Color Hexagon were used to make a graphical analysis of the color gamuts. Rather than show only the solid as they appear, I chose to show where the cyan, magenta, yellow, red, green and blue patches appear on the GATF Color Hexagon for a normal separation, a normal separation printed with two process inks, and the Markolor two-color separation combinations, with the red with black, green or blue inks. It is also possible to add a modified yellow printer when there are more printing units on the press. This three color and the normal two-color seps are not shown on the color hexagons.

You can see from the different hexagons that there is no yellow ink. However, there is information printing in the yellow patch. I have indicated where the measured patches for that missing color appear in the hexagon. It is normal to zero-out the densitometer on the substrate when making these measurements. However, I felt that to zero-out the densitometer on the paper would only warp the measurements and not show what we see.

Dot area readings of the separation negatives taken in the Kodak Q-60 illustrate how the dot sizes of the Markolor separations differ from those made for normal four-color process separations. The Markolor black is a full-scale separation. It is needed to produce the detail and tone rendering in the highlight end of the tone scale.

4-Color Black Printing Dot Sizes

	C	M	Y	K	R	G	B
A							
B							
C							
D							
E							
F	1	1	0	4			
G	1	0	0	14			
H	6	0	0	28		4	6
J	13	2	0	43		12	11
K	23	6	0	60	3	23	16
L	26	10	0	72	7	30	23
M	29	14	0	81	11	41	33

2-Color Black Printing Dot Sizes

	C	M	Y	K	R	G	B
A	6	6	6	6	6	6	5
B	9	5	5	9	5	8	8
C	15	4	5	14	2	11	14
D	23	3	3	25	4	18	20
E	29	5	2	38	6	30	30
F	38	7	0	52	7	42	43
G	47	8	0	65	8	56	57
H	59	8	0	76	9	66	70
J	67	9	0	85	9	75	81
K	73	10	0	91	9	80	87
L	78	11	0	95	9	84	90
M	82	13	0	96	11	88	92

4-Color Magenta Printing Dot Sizes

	C	M	Y	K	R	G	B
A	4	4	4	5	4	4	5
B	4	5	5	5	5	4	5
C	4	6	5	7	7	4	6
D	4	17	5	12	15	4	13
E	4	31	5	21	31	4	24
F	5	51	5	33	50	5	37
G	6	65	8	46	65	5	55
H	8	77	12	57	78	5	67
J	10	87	17	67	88	5	76
K	12	95	22	79	96	5	83
L	15	98	27	87	99	7	89
M	22	99	40	94	100	22	93

2-Color Red Printing Dot Sizes

	C	M	Y	K	R	G	B
A	4	4	4	4	4	4	3
B	3	6	4	5	5	2	5
C	2	7	5	8	7	0	8
D	1	16	5	12	14	0	12
E	0	27	6	18	26	0	21
F	0	43	7	27	42	0	31
G	0	58	7	34	59	0	44
H	0	71	10	38	71	0	57
J	0	83	13	42	84	0	63
K	0	91	17	49	93	0	69
L	0	97	21	55	98	0	76
M	0	100	32	59	100	0	78

CONCLUSION

The visual effects gained from using this Markolor two-color separation and printing technique can add significantly to the image content of a color reproduction. The reduced printing costs of only printing two colors makes it possible to use color printing with graphic images more frequently. It also allows you to choose the second color that corresponds to a background color, a trademark color or important product color, and to print these colored images on colored paper. The Markolor image represents a significant improvement over a black-only image. Color always attracts attention.