PRINT QUALITY MEASUREMENTS IN OFFSET LITHOGRAPHY

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Abstract: An instrumental method that accounts for direct influences of ink--paper, ink--press and paper--press interactions on image quality of imprints is reported. The method is based on general principles of optical information transfer and studies of the human perception of visual information. It utilizes the measurements of a contrast as a function of image's spatial frequencies. These measurements are performed using specially designed target and accomplished by a computer driven densitometer with following data processing so that the print quality is expressed by a number $0 < Q < 1$. The method was applied to measure Q for a sheet fed 4-color press. The ink film thickness and paper stock were the variables in the study. The results show clear maxima of print quality that can be achieved for the given ink--paper--press combination.

Introduction

It was demonstrated by Sayanagi (1956) in his study of photographic lenses and by Granger and Cupery (1972) for photographic images, that the area under the well known in optics Modulation Transfer Function or MTF (Dainty, Shaw 1974) can be used as a measure of quality of an imaging system. The same conclusion was obtained later for TV systems (Infante, 1985; Barten, 1987). Granger and Cupery (1972), using a weighting factor accounting for significance of spatial frequencies perceived by a human eye, and implementing a frequency bandpass model of human vision, successfully correlated human perception of picture quality with the ratio of MTF areas corresponded to an imaging system and an eye.

Direct application of the same approach for printing seems impossible because of the micro-binary character of the lithographic process: ink is either transferred onto the

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paper or the paper is left blank. The halftones are simulated by creating larger or smaller dots placed with the same spatial frequency on a printing form by a screening process. The apparent linearity of tone reproduction is achieved by involving the human eye as a spatial integrator into the process of image viewing, thus converting micro--binary lithography to a macro--linear imaging system. As it was shown by Gur and O'Donnell (1987a,b) for digital printers and by Infante (1987) for color CRT with shadow masks, the idea of MTF can be expanded to account for a system's macro--linearity. This macro--MTF was called Contrast Transfer Function (CTF) in the article by Gur and O'Donnell (1987b) and an averaging experimental procedure was suggested for its measurements using the idea of a square wave image. If the cascading property of the MTF is *a priori* extended to the CTF, then the area under CTF can be related to the area under the MTF of a human eye. This ratio was used by Gur and O'Donnell (1987a) as a measure of perceived print quality of characters printed on a digital printer.

Current work presents the results of further generalizations of the approach with its applications to 4-color lithography.

Procedure

A special target image with variable spatial frequencies was designed and is presented in Figure 1. The negative of this image was carefully measured to determine actual

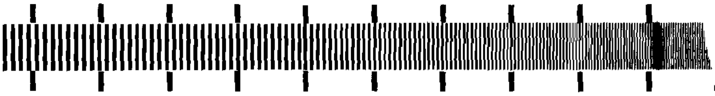

Figure 1. Part of actual target image.

frequencies in the positions of interest. These positions are marked in Figure 1 with small ticks. The negative was used to make a printing form which was created by a translation of the target image in a step-and-repeat machine. 11 images of the target were placed across the 40" form for every processing ink together with solid areas of approximately 1" width.

The form was mounted on 40" Royal Zenith 4-color Planeta press. Ink keys of the press were controlled from the console and Figure 2 presents the actual key settings for the experiment. Control of the density of solid areas in time of print assured the absence of ink film thickness variations

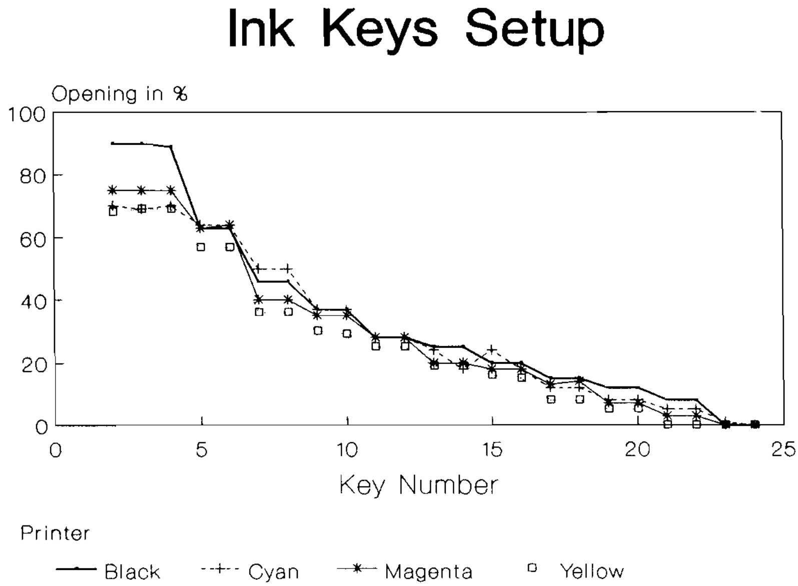

Figure 2.

over the width of any selected target. Experimental press run was made on coated and uncoated paper stock.

Printed images were measured by a computer controlled densitometer. Special software was written that 1) assisted to operator in data acquisition, 2) performed all necessary conversions of the density to reflectance, 3) computed actual contrast values for every spatial frequency measured, and 4) calculated Q values of quality using the algorithm that resembled the one published by Gur and O'Donnell (1987b). Intermediate results were stored for future references.

Results and Discussion

Figure 3 presents typical results in measurements of the CTF. Contrast transfer was lower for uncoated than for coated paper for every key setting studied in the experiment. The resulted print quality that is proportional to the area under the CTF curve was 20-40% lower for uncoated stock than for coated one printed in the same experimental conditions.

All tested inks showed typical behavior of the CTF relative to the initial ink film thickness. Thick films (high key opening) increased the contrast in the areas of low spatial frequencies while the high frequencies showed significant decrease.

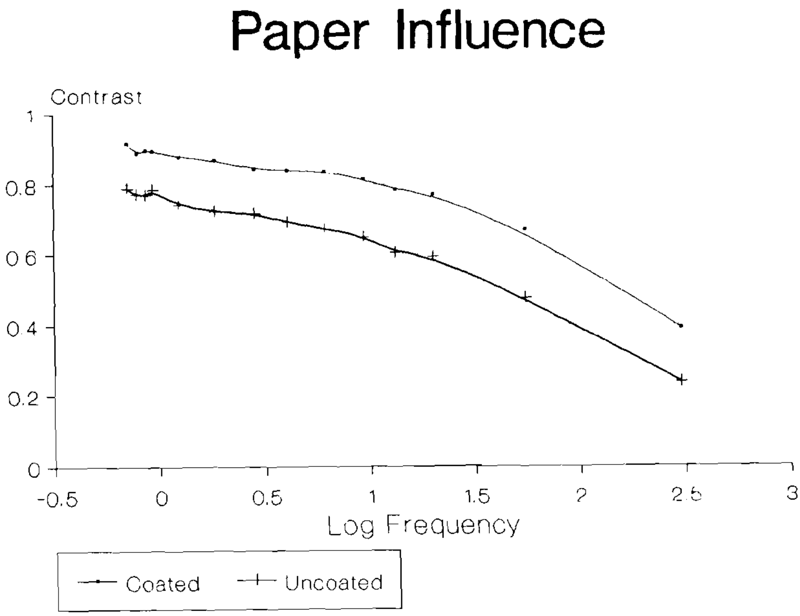

Figure 3.

This is clear from Figure 4, where thick film situation is presented by a thick solid curve. Very thin film of ink (low key opening) led to improvements of the contrast in the high frequencies, but visibly reduced the contrast in low frequencies areas, as illustrated by a dashed curve in Figure 4. It is possible to find the key opening that produces an optimal ink film thickness, sufficient for acceptable reproduction of the contrast in high frequencies areas without a significant degradation of the contrast in low frequencies. Such curve is plotted as a thin solid line in Figure 4.

The existence of optimal ink key openings (ink film thicknesses) is obvious from Figure 5 where the final values of print quality, calculated from CTF characteristics similar to Figure 4, are presented as functions of the inking keys positions. Curves for all processing inks show the presence of a maximal point. The position of the maximum is different for different inks which is a direct consequence of the physico--chemical differences between inks.

In our opinion, the width of these curves (sharpness of

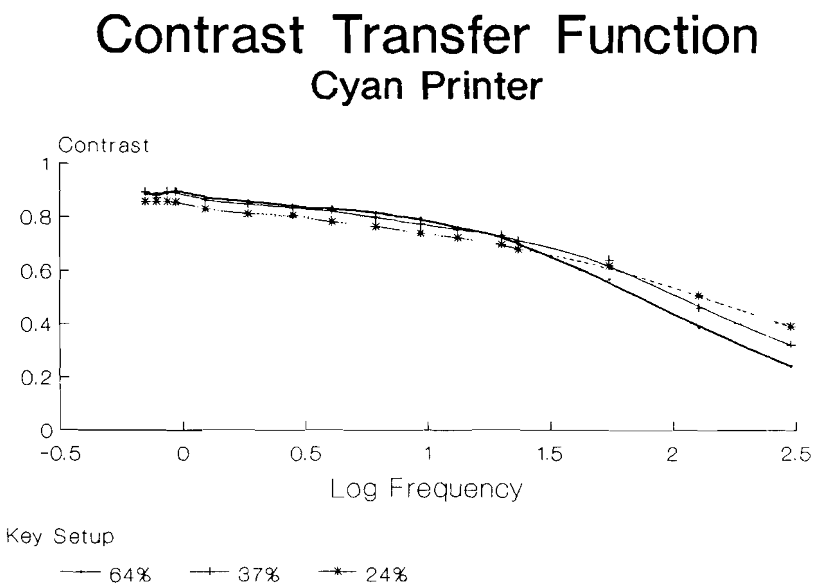

Figure 4.

the maxima) is in direct connection with the ink--paper interaction, but the acquired experimental material is insufficient to make any functional connections. It is clear, however, that the inks with a wide maximum are more forgiving on the press allowing more degrees of freedom for fine color adjustments without a significant lost of the contrast transfer.

The maximal point on the print quality diagrams, Figure 5, can be used to define the solid cover density that corresponds to the optimal contrast transfer. Color characteristics of the optimal solid cover can be measured and related to a color separator to assure the right color reproduction negatives with maximal print quality.

Conclusions

The Contrast Transfer Functions can be used for objective judgments of print quality.

An instrumental method of print quality measurements was implemented and applied to lithographic printing process.

The method can be used in ink--paper interaction studies

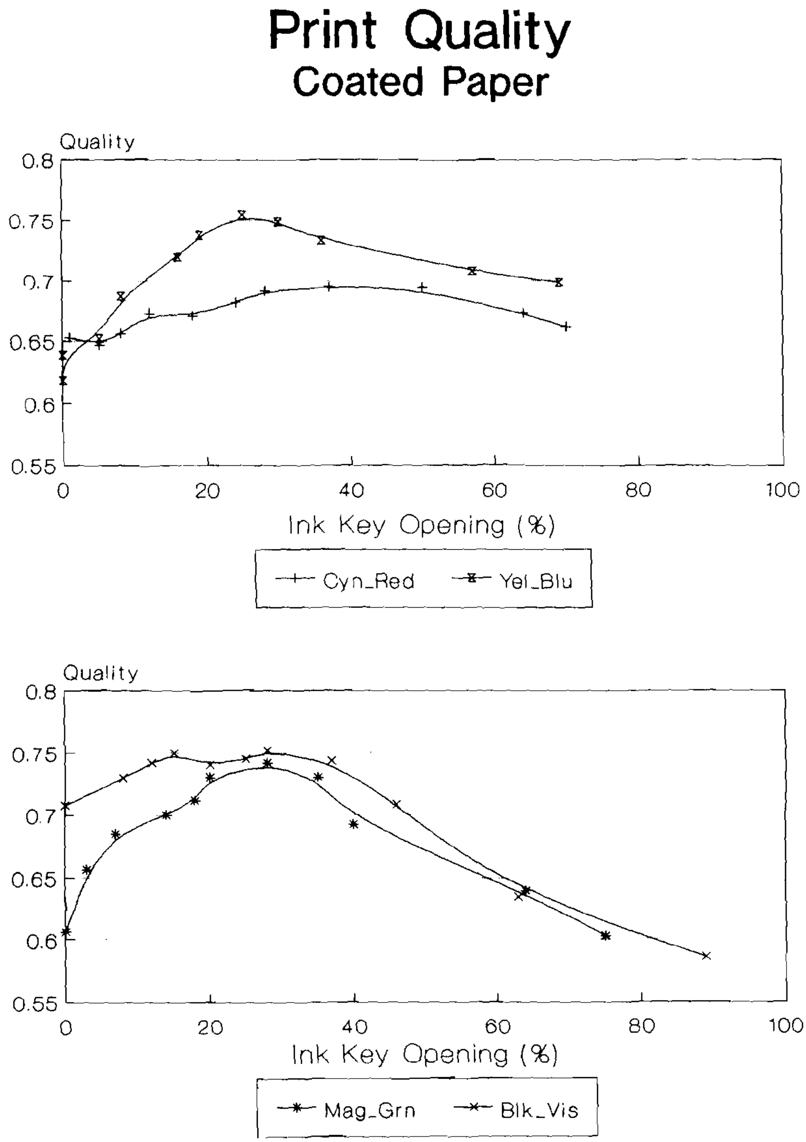
Print Quality
Coated Paper
Quality
0.8
0.75
0.7
0.65
0.6
0.55
0
20
40
60
80
100
Ink Key Opening (%)
Cyn_Red
Yel_Blu
Quality
0.8
0.75
0.7
0.65
0.6
0.55
0
20
40
60
80
100
Ink Key Opening (%)
Mag_Grn
Blk_Vis

Figure 5.

or as a tool to select the best paper--ink combinations for a given press.

The method can be applied to find or verify the optimal solid cover densities, often used as the only production control, for a given paper--ink combination.

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