GRAVURE PRINTABILITY FROM LASER AND ELECTROMECHANICALLY ENGRAVED CYLINDER

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ABSTRACT

Gravure printability comparison of laser engraved and electromechanically engraved cylinders was done on five different substrates. Ink transfer was less reduced on laser print than electromechanical when printed without electrostatic assist. Print mottle was significantly lower at yellow, magenta and black laser engraved images, while cyan print from laser engraved cylinder had higher mottle on some substrates (SCB, SCA and freesheet). Overall, the print from the laser engraved image had better print quality than that from the electromechanically engraved one.

RÉSUMÉ

La comparaison d'imprimabilité de gravure des cylindres laser gravés et électromécanique gravés a été faite sur cinq substrats différents. Le transfert d'encre a été moins réduit sur la copie de laser qu'électromécanique quand imprimé sans aide électrostatique. La marbrure d'impression était sensiblement inférieure au jaune, magenta et noire images gravées par laser tandis que cyan imprimez du cylindre gravé par laser a eu une plus haute marbrure sur quelques substrats. De façon générale, la copie du laser gravé l'image a eu une meilleure qualité d'impression que cela de électromécanique gravée.

INTRODUCTION

Laser engraving of gravure cylinders is the latest and most exciting development introduced by the Daetwyler laser engraving system [1]. The Daetwyler Direct Laser System (DLS), now being used in the gravure market, features galvanic plating of the zinc/chrome layers that meets the surface structure and durability requirements for the gravure process [2]. The laser beam, focused onto the cylinder surface, melts and vaporizes the image-carrier material and produces the cells. Laser engraving allows for larger variability in cell shapes and their sizes. These new shapes can result in higher print densities. By dynamically controlling the laser beam diameter, width and depth of cells can be individually configured for publication and package printing. Laser-engraved cells are actually spherical in shape, providing improved ink release. For example, to achieve a comparable printing density, the depth of a laser cell is only approximately 2/3 of an electromechanically engraved cell [3]. Consequently, finer screens are possible, while still obtaining the required print density. With laser technology, it is possible to create also variable shape cells, not achievable with electromechanical engraving [4]. These new shapes actually provide for higher print density and it is possible to use higher viscosity inks than with traditional electromechanically engraved cylinders. Experiments showed that laser engraved cylinders reduce the influence of press printing speed on print quality [4], and keep stable highlight tone values. A zoom optics allows for a screen resolution from 178 to 1016 lpi. Direct laser engraving is a non-contact method, which does not cause wear of engraving tool and is therefore capable of producing consistent engraving [5]. It seems that laser engraving offers multiple benefits. The laser system operates 17 times quicker than current engraving machines [1] and reaches speeds of 70,000 cells per second. Compared to electromechanical systems, laser provides for higher and more uniform quality and shorter make-ready, with a minimum of color shift and moiré [2]. With the laser process, there is no traditional rosette pattern dot and, therefore, no limitations on screen angles and a more neutral gray balance is created. The vignette is printed as a continuous tone, even down to a 20 percent step. Although expensive to install, laser technology should not increase the cost of gravure printing, and because of greater repeatability, it will automatically show cost savings to the converter [1]. The aim of this work was to compare printability results for electromechanically and laser engraved gravure image carriers.

EXPERIMENTAL

Four publication substrates [Light Weight Coated, 42 lb/ream (LWC), Supercalendered B, 35 lb/ream (SCB), Supercalendered A, 35 lb/ream (SCA), Freesheet, 45 lb/ream (FS) and one packaging Solid Bleached Sulfate, 81 lb/ream (SBS) board] were used in this experiment. Some of their papermaking properties are listed in the **Table I**, and optical properties in the **Table II**.

Table I: Selected papermaking properties

Substrate	PPS Roughness at 500kPa [μ]	PPS Roughness at 1000 kPa [μ]	PPS Porosity [mL/min]
LWC	2.13	1.63	7.12
SCB	2.02	1.55	14.15
SCA	2.21	1.65	23.31
FS	1.98	1.48	16.46
SBS	3.58	2.53	1.46

A Cerutti pilot-plant rotogravure web printing press (Cerutti Model 118, Italy) was used to print test samples. Two sets of cylinders were used for printing: electromechanically engraved (EE) and direct laser engraved (LE). The screen ruling was 140 lpi (lines per linear inch) for yellow, 175 for magenta, 175 for cyan and 225 lpi for black cylinder, with compression angles 45 °, 60°,

Table II: Selected optical properties

Substrate	Specular Gloss 60 °	Brightness [%]	Opacity [%]
LWC	17.16	71.50	86.89
SCB	14.51	65.78	88.56
SCA	15.88	68.19	87.42
FS	20.46	79.32	92.65
SBS	14.25	83.75	95.59

30°, and 45°, respectively. The screen ruling at laser engraved cylinders (tone work) was engraved at 254 lpi (100 lc lines per centimeter) for all cylinders. Black engraving, the Line Work (LW) was engraved with the 278 lc Masterscreen pattern. The laser engraved cells were angled at 30 degrees. All of the cylinders were engraved at the same angle. The image on both cylinders was the same with small variations (IT 8.7/3 chart was included in laser imaged cylinders). Four process colors were printed at 305 m/min (1000 ft/min) for LWC, SCB, SCA and freesheet. The speed of 600 ft/min was run for SBS board. Commercial toluene based coated group VI inks were employed. Their efflux time ("printing viscosity") was 22 seconds on a Shell #2 efflux cup for yellow, magenta and cyan inks and 20 seconds for black ink. The same ink viscosity was used for both sets of cylinders. Thus, ink viscosity was not optimized for laser engraved cylinders for comparison reasons. Oven dryers were set to 60 °C at 9000 cfm nozzle velocity. Electrostatic assist (ESA) was applied at 4 kV and 1.4 mA (ESA on), 25% ESA (1kV), and ESA off. All the settings were kept the same when printed with both sets of cylinders.

Parker Print-Surf Model ME 90 (Messmer Instruments Ltd., U.K) was used for both porosity and roughness measurements. Brightness was measured by Brightness-X-Rite 8400 instrument equipped with Color Master software. Substrates opacity was measured according to TAPPI Standard T 425-om-91.

Image analyses of magenta, cyan, and black dots were recorded at 5 % tone step using a Hitachi HV-C10 camera (Hitachi Denshi, Ltd., Japan). Computer software Image ProPlus, Version 4.5 was used for image detail analysis. Print density mottle was measured using a Tobias Mottle tester with reflective density head. Tobias mottle was compared to mottle measured using Verity 1A Multifunction 2003 software. Solid process colors were scanned by HP Scanjet 7400C scanner at 600 dpi resolution as input images for Verity software to calculate mottle. For mottle calculation in Verity 1A software, tile sizes 2-1024,2-64, 4-1024 and 4-64 were used. According to the instruction, tile size 4-64 represents visible mottle. Reflective density, tonal responses, and dot gain were measured using X-Rite 530 Spectrodensitometer. Specular gloss was measured by Gardner Gloss Meter with 60 degree geometry on solid colors and the gloss was calculated as average of five measurements in paper machine and five measurements in cross-machine direction.

RESULTS AND DISCUSSION

Selected papermaking characteristics of substrates used in trial are listed in the **Table I**, and **Table II**. Dot gain curves were measured for all inks, substrates and different levels (100%, 25% and 0%) of ESA (Electrostatic assist). Dot gain curves for laser engraved cylinders were generally smoother than those from electromechanically engraved cylinders (See **Fig. 1** and **Fig. 2**).

Maximum dot gain for laser engraved cylinders was found at 30 to 40% tone, while at electromechanically engraved print it was at 50% tone. Maximum dot gain was averaged for all five substrates and each ink (**Tab. III**). It was found that dot gain from L (laser engraved) cylinders (29.10-24.10 %) was greater than from E (electromechanically engraved) cylinders (24.80-19.98) on all substrates and all inks (**Tab. III**), which was probably due to slightly higher screen ruling at laser engraved cylinders.

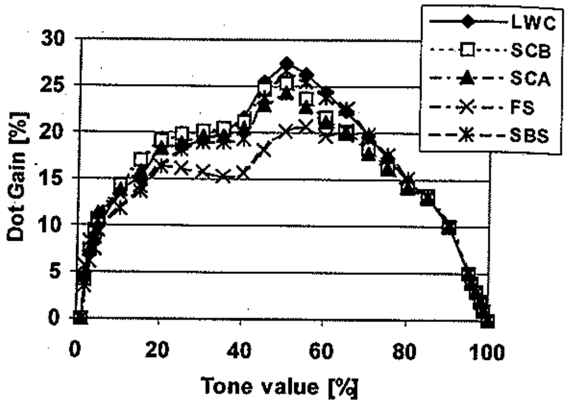

Figure 1: Magenta dot gain from electromechanically engraved cylinder, ESA on

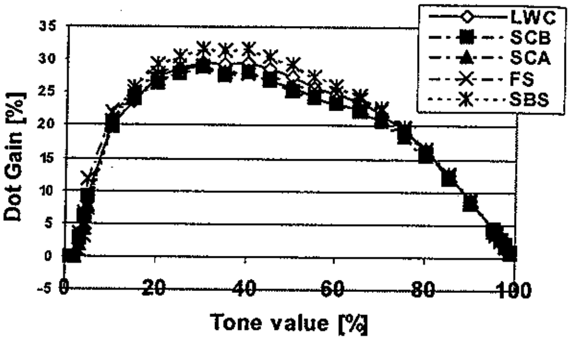

Figure 2: Magenta dot gain from laser engraved cylinder on various substrates, ESA on

Printing without electrostatic assist (ESA off) affects ink transfer from laser engraved cells less than from electromechanically engraved cells, which was obvious when subtracting average dot gain values ESA on and ESA off (**Table III**). The differences in an ink transfer between ESA on and off for E cylinders were between 3.48-1.82 and for L cylinders between 2.24-0.14, which clearly shows much smaller differences in dot gain, thus in an ink transfer, between ESA on and off. The smallest difference was found at black print, which is probably due to high efficiency of ink transfer from multi-shot laser engraved cells. Example of dot gain curves at LWC with ESA on, 25% ESA and ESA off are illustrated in the **Fig. 3** and **Fig. 4**.

Table III: Average dot gain on all paper/board substrates (E at 50% and at L at 40% tone, dot gain for all substrates was averaged)

Color	E/ESA on	E/ESA off	L/ESA on	L/ESA off
Yellow [%]	19.98	18.10	24.54	23.94
Magenta [%]	24.80	21.60	29.10	28.70
Cyan [%]	20.70	18.60	24.10	21.86
Black [%]	20.80	18.98	27.68	27.54

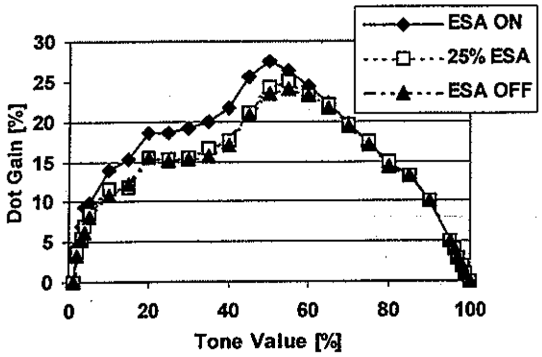

Figure 3: Dot gain at LWC from electromechanically engraved cylinder at various levels of ESA

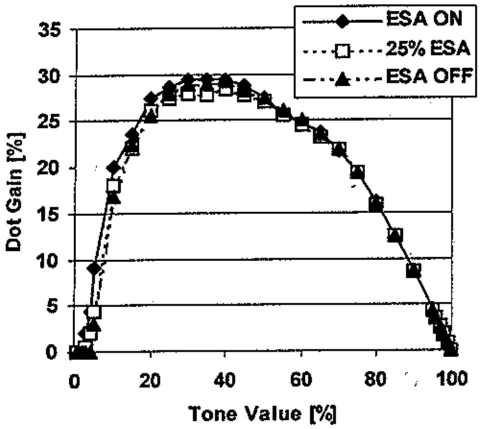

Figure 4: Dot gain at LWC from laser engraved cylinder at various levels of ESA

Reflective density of solid prints was higher printed from electromechanically engraved cylinder than from laser engraved one for yellow, magenta and cyan (Data not shown). Only solid black showed opposite trend - much higher reflective density was achieved from LE cylinder, and this was true for all substrates. Higher optical density of black print was most likely due to multi-shot black laser engraved cells. Again, the ink viscosities were not optimized for laser engraved cylinders for comparison reasons.

Specular gloss was measured at solid print areas. In most cases, different substrates printed with laser engraved cylinders gave slightly higher gloss values, and this was most apparent on black print, especially with ESA off (Fig. 5). This means that ink film is better leveled at laser print- which may be due to round and shallower shape of laser engraved cells.

Print mottle can be measured as unevenness in print density, gloss or color. The higher the mottle index number, the worse the unevenness. In this work, Tobias density mottle index and Verity mottle were measured.

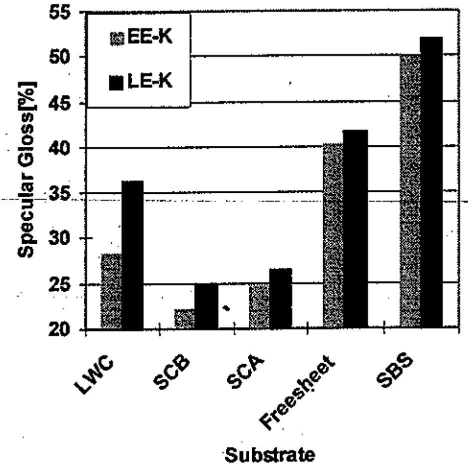

Figure 5: Specular gloss of black solids printed from electromechanically and laser engraved cylinder (ESA off)

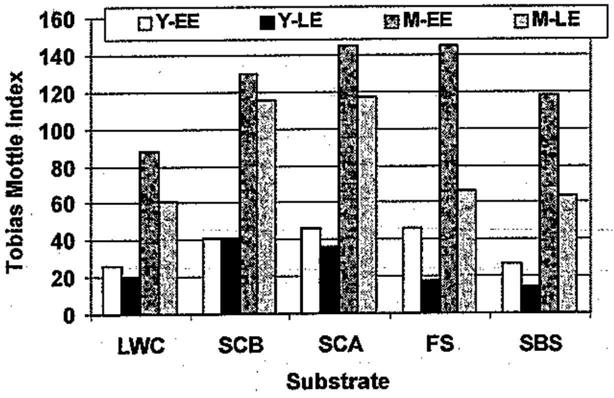

Figure 6: Tobias Mottle of yellow and magenta on different substrates from E and L cylinders

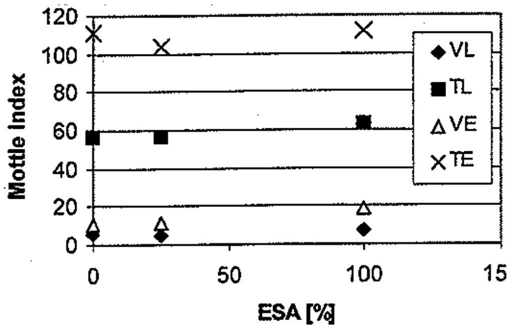

Figure 7: Comparison of mottle measured on solid cyan (TL=Tobias/laser engraved, TE = Tobias/electronic engraving, VL= Verity/laser engraved; VE= Verity/electronic engraving)

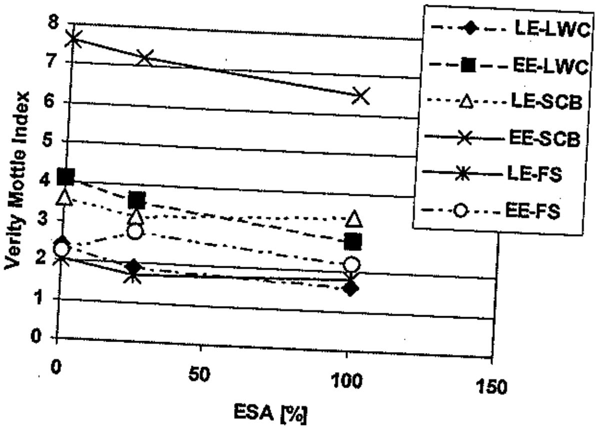

Figure 8: Verity mottle index at black print at various substrates and ESA levels

Verity Multifunction software analyzes digital images, acquired by a sensitive scanner. The algorithm is built to calculate pixel intensity difference of a scanned image [6, 7]. Verity Mottle is a function of the mean pixel luminance and the standard deviation of pixel intensity. Tobias density mottle index for yellow and magenta print from EE and LE cylinders is illustrated in the **Fig. 6**. Images from laser engraved cylinders exhibit lower mottle index, thus show better print uniformity.

Comparison of cyan print mottle at all ESA levels measured by Tobias Mottle Tester and by Verity software is illustrated at **Fig.** 7. Both Verity and Tobias show that laser engraved images give lower print mottle. Lower mottle for laser engraved cylinders was found at all levels of electrostatic assist and all substrates printed with yellow, magenta and black. Cyan print from LE cylinder had higher mottle at SCA, SCB and freesheet at all ESA levels. In most cases, print showed lower mottle at ESA on than ESA off (**Fig. 8**) at both LE and EE cylinders, which is probably due to better ink transfer and lesser amount of missing dots when ESA on.

CONCLUSION

Comparison of gravure printability from laser and electromechanically engraved image carriers was done on four publication and one packaging gravure paper substrates. The same ink viscosity was used for electromechanically and laser engraved cylinders for comparison reasons- ink was optimized for electromechanically engraved cylinders. On all substrates and all process color inks, the dot gain was greater from laser engraved cylinders than from electromechanically engraved ones, which was most likely due to slightly finer screen ruling at laser engraved cylinders. The difference in dot gain with ESA on and ESA off was much lower for laser engraved cylinders for all inks and substrates, which means that ink transfer is much better from laser engraved image carriers. Print gloss was slightly higher on images from laser engraved cylinders. Laser engraved cylinders produced lower print mottle on most substrates and colors. Comparing all of these printability features, it can be concluded that laser engraved images produce better print quality than electromechanically engraved ones.

ACKNOWLEDGEMENT

Authors would like to thank Keatings Gravure, Inc. for the donation of laser engraving and to Max Daetwyler, Inc. for the transportation of the cylinders to WMU, Kalamazoo. We are also thankful to Mr. Doug Cox, Director of the Printing Pilot Plant, Western Michigan University, for arranging the printing trials and Mr. Roy Rosenberger for the donation of Verity 1A LLC software for mottle evaluation as well as for valuable discussions.

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