Quality of Digitally Printed Paperboard for Folding Cartons

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Abstract

The global market for digitally printed packaging grows rapidly. This study focused on using dry and liquid toner system to print on regular paperboards, which are originally for lithographic or flexographic printing. Uncoated, gloss coated, and cast coated paperboards with different calipers were tested. The paperboards were printed with and without surface treatment to modify paperboard surface energy. The printed paperboards were folded with and without scoring. The folding occurred at printed areas including single color and multiple color overprints. To study the contribution of varnish to folding quality of paperboard, printed paperboards were applied aqueous coating. The folding quality was evaluated under microscope and calculated by density variation. The results showed that folding cracked the ink film printed with dry and liquid toner. Coated paper had less folding cracks than uncoated paper. With increasing paper caliper, the folding got worse. Scoring improved folding quality.

Introduction

The global market for digitally printed packaging and labels grows rapidly. According to Pira International (Packgaing, 2010), the market of digitally printed packaging and labels is forecasted to grow by an overall 182 percent to reach close to $6.8 billion by 2014. A major driver for digital printing is the need for customization and shorter press runs, in order to minimize inventories. Digital, on demand printing of packaging and labels reduces waste and makes the business more competitive on the market. Pira predicted that among digitally printed forms related to packaging,

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digitally printed labels will take about 56 percent of the total market, digitally printed labels will take about 56 percent of the total market, digitally printed corrugated boxes will be over 13 percent. Besides tags, the fourth-largest segment is digitally printed folding cartons, which will be about 7.8 percent of the market by 2014.

Many different applications require digitally printed folding cartons, which include mock-ups and prototypes for packaging designer, personalized boxes for cosmetic and pharmaceutical needs, and etc.

There are few studies done which are related to print quality, folding cracks, and toner adhesion of digitally printed paperboards. Print qualities, such as line/text quality, color gamut, and detail reproduction have been investigated (Linna, 2000). It was found that digital printing could print on a large variety of substrates. The substrates had strong effect on image quality. Some types of the substrates may not be able print with an electrophotographic printer due to fusing heat.

The functionalities of digitally printed packaging including taste and odor, creasing, toner adhesion, stability of whiteness of printed paperboards were studied (Gidlöf, 2004). It was found that the toner adhesion showed problem with liquid toner printed samples. There were folding cracks occurred during manual folding.

To understand the effect of surface properties to toner adhesion, the study has been done to modify the polymer- coated packaging paperboards surface before printing (Lahti, 2004). The study showed that paperboard modified with electrical corona discharge treatment improved print quality and toner adhesion.

This study focused on experimenting the folding quality of paperboard printed with dry and liquid toner system. The substrate thickness, coated and uncoated paper, surface modification of coated paper with corona treatment, and the final finish on printed ink film were investigated to understand the influence of the factors to the folding quality.

Experiments

Paperboards for the experiments were 12pt uncoated, 12pt gloss coated, 12pt cast coated, 14pt uncoated, and 15pt uncoated. Presses run were HP Indigo 3050 with liquid toners and Ricoh C900S with dry toners. Part of the paperboards were surface treated with a Lab Corona Treater to compare with the ones with no surface modifications.

The graphics for printing were single black and overprints of black, cyan, magenta, and yellow. Half of the printed samples were applied aqueous coating, which is formulated for offset printing.

The printed and aqueous coated samples were scored through a MBO folding machine. Scores were applied along the machine-direction of the paperboard. The scored samples were hand folded along the folding scores. The samples were also hand folded without scoring to compare the folding quality.

The paperboards were folded at 180 degree and then unfolded. The folding lines were investigated under microscope and scanned. The gray levels of the folding line were inspected with ImageJ (ImageJ) software. The variation of gray level were measured and recorded.

Results and Discussions

The experiments were to investigate the correlation of paperboard properties, printing, and folding conditions to folding quality.

After printing, the single layer of black and overprinted black, cyan, magenta, and yellow were scored and hand folded. The folded and unfolded samples were scanned with an Epson Perfection 4490 scanner with no image adjustments.

Figure 1 showed the samples printed and folded with different conditions. Printed paperboards were applied aqueous coating before being folded. The paperboard printed was 12 point uncoated.

Figure 2 showed the samples printed under the same conditions as in

Figure 1. The printed paperboards were not applied aqueous coating before being folded.

For each sample, the left line was folded with scoring, the right line was folded without scoring.

Figure 1: *Printed and folded paperboards with aqueous coating applied. Folding lines were scanned with an Epson scanner. The left one was printed with Ricoh C900S. The paperboard was not corona treated. The middle one was printed with HP Indigo 3050 on the untreated paperboard. The right one was printed with HP Indigo 3050 on the corona treated paperboard.*

Figure 2: *Printed and folded paperboards without aqueous coating applied. Folding lines were scanned with an Epson scanner. The left one was printed with Ricoh C900S. The paperboard was not corona treated. The middle one was printed with HP Indigo 3050 on the untreated paperboard. The right one was printed with HP Indigo 3050 on the corona treated paperboard.*

The scanned images were measured with ImageJ. The parameters set for measurements included min/max gray value, median gray value, and gray value standard deviation. The folding quality was defined as the degree of cracking. The standard deviation of gray value was used for evaluating the degree of cracking. The higher degree of cracking appeared to have higher standard deviation of gray value. The standard deviations of gray value were plotted in the figures (**Figure 3-7**). In the figures, "CMYK SCORED" represented the folding done on scored overprinted black, cyan, magenta, and yellow; "K SCORED" represented the folding done on scored single black print; "COATED CMYK SCORED" represented folding done on aqueous coated, scored, overprinted black, cyan, magenta, and yellow; "COATED K SCORED" represented the folding done on aqueous coated, scored, single black print.

Folding quality and paper coating

To understand the correlation of folding quality and paper coating, 12pt paperboard uncoated, gloss coated, and cast coated were studied.

Figure 3 showed that on 12pt uncoated paperboards, dry toner film appeared more cracks than liquid toner film. Corona treatment on paperboard surface did not improve folding quality. The aqueous coating on printed ink film did not improve folding quality.

Figure 4 showed that on 12pt cast coated paperboards, dry toner film and liquid toner film had similar folding quality. The cracks were less severe than the ones on uncoated paperboards. Surface treatment and aqueous coating did not improve folding quality for cast coated paperboards.

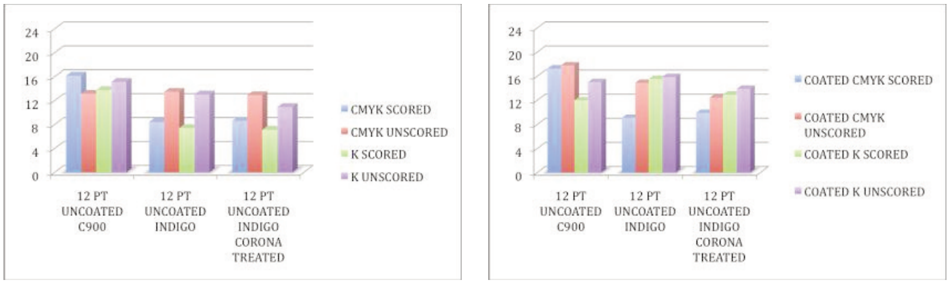

Figure 3: *Gray value standard deviations of folded lines. The paperboards printed were 12pt uncoated. The upper chart represented the folding done without applying aqueous coating. The lower chart represented the folding done after aqueous coating applied.*

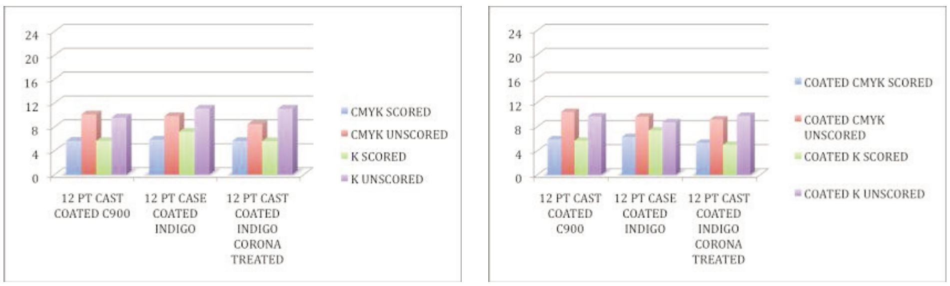

Figure 4: *Gray value standard deviations of folded lines. The paperboards printed were 12pt cast coated. The upper chart represented the folding done without applying aqueous coating. The lower chart represented the folding done after aqueous coating applied.*

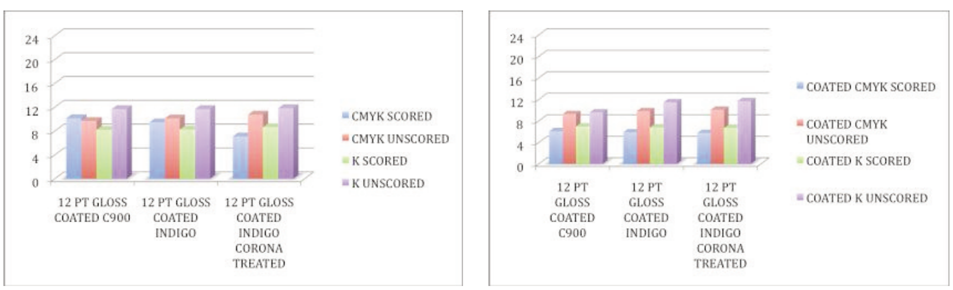

Figure 5: *Gray value standard deviations of folded lines. The paperboards printed were 12pt gloss coated. The upper chart represented the folding done without applying aqueous coating. The lower chart represented the folding done after aqueous coating applied.*

Figure 5 showed that on 12pt gloss coated paperboards, dry toner film and liquid toner film had similar folding quality. Surface treatment and aqueous coating did not improve folding quality.

Some cracks appeared on uncoated paperboards were introduced by scoring. The cracks might also be the results of low flexibility of uncoated paperboards.

Folding quality and paper thickness

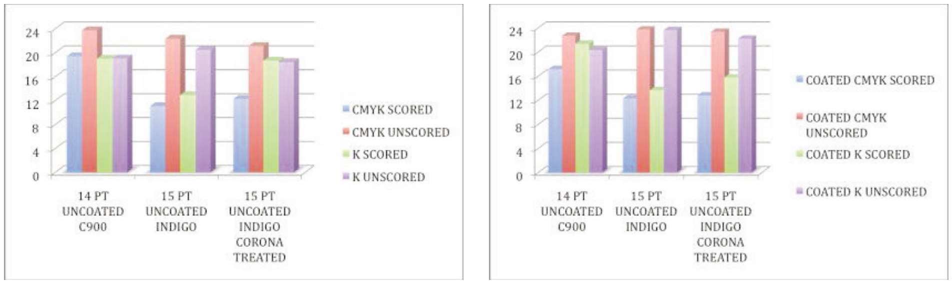

Figure 6: *Gray value standard deviations of folded lines. The paperboards printed were 14-15pt uncoated. The upper chart represented the folding done without applying aqueous coating. The lower chart represented the folding done after aqueous coating applied.*

Folding quality is related to paperboard thickness and ink film flexibility. Paperboards with different thicknesses were tested. HP Indigo 3050 could print up to 15pt in thickness. Ricoh C900S could print up to 14pt in thickness.

For comparison purpose, 14pt uncoated paperboard printed with dry toner and 15pt uncoated paperboard printed with liquid toner were chosen.

Figure 6 showed that on 15pt uncoated paperboard (14pt for Ricoh C900S), dry toner film appeared more cracks than liquid toner film. Surface treatment and aqueous coating did not improve folding quality.

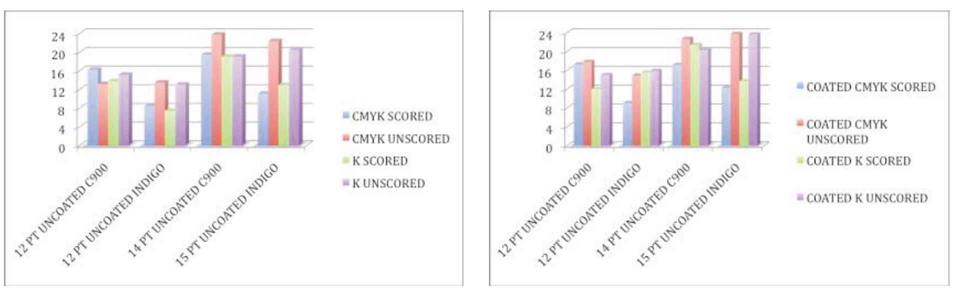

Figure 7: *Gray value standard deviations of folded lines. The paperboards printed were 12, 14, and 15pt uncoated. The upper chart represented the folding done without applying aqueous coating. The lower chart represented the folding done after aqueous coating applied.*

Figure 7 showed that with increasing of paper thickness, more cracks appeared after folding. Dry toner film appeared more cracks than liquid toner film. Aqueous coating did not improve folding quality.

Folding quality and folding method

The printed samples were folded in two different ways. One way was to fold the printed paperboard after scoring. One way was to fold the printed paperboard without scoring. As shown in **Figure 3-6**, scoring improved folding quality by introducing less cracks for liquid toner printed paperboards. For dry toner printed paperboards, scoring did not improve the folding quality much.

Folding quality and ink film thickness

The paperboards were printed with single layer of black and overprinted black, cyan, magenta, and yellow. Two different types of ink film were scored and folded. As shown in **Figure 3-6**, there was no evident to show overprinted ink films cracked more than a single layer of ink.

Conclusions

This study investigated the possibility of printing folding cartons by electrophotography. A liquid toner system and a dry toner system were employed to understand folding quality in terms of the degree of cracking. The printed paperboards were scored and applied aqueous coating. The influence of scoring and coating to folding quality was studied.

The results showed that the thickness of paperboard had strong influence to folding quality, the thicker the paper, the worse the folding. Scoring improved folding quality when applied on liquid toner printed paperboard. Dry toner printed paperboards did not benefit from scoring much.

Paperboard coating somehow affected folding quality. Folding had less cracks on coated paper verse on uncoated paper. This might be related to scoring procedure, which introduced cracks while scoring. More experiments are needed to understand how the scoring settings, such as scoring wheel, scoring pressure affect the folding quality.

Corona treatment intended to modify the surface property of paperboard. The results showed that surface treatment had little to no impact to folding quality.

Aqueous coating was applied on printed paperboard to understand how the clear coating affects folding quality. The results showed that applying aqueous coating did not improve the folding quality on either coated or uncoated paperboards.

Digitally printed paperboards could introduce variable information to packaging and achieve short run, fast turnaround. As for folding carton, toner-based printing has many limitations. Toner-based system can print on paperboards with limited thickness. The thickness of paperboard for folding carton ranges from 12 point to

32 point. Many toner-based production systems can run paper up to 15 point in thickness. Some toner-based system may run up to 26 point in thickness. This limits the form of folding cartons can be made. Another challenge is the folding quality. The folded paperboard showed cracks no matter folding with scoring or not. This affects the appearance of the folding carton.

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