Stripes and »stripes«

A proposal on how to evaluate the relationship between stripes in print and wash-boarding

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Printing on corrugated board often results in visible stripes which coincide with the flutes of the board. The print is mostly darker on top of the flutes than between the flute. This phenomenon is most visible when printing halftones directly onto corrugated board. *Figure 1* shows how the stripes can appear in a printed halftone area.The industry has, for many years, explanations and solutions for the problem. Some of the solutions really work and help to reduce the visibility of the stripes. However the explanation as to why the solution works does not always stand-up against common sense and fundamental knowledge.

Providing »black art science« with a working solution might sell the solution well in the beginning but it is the biggest restraint on the innovation of the proposed solution. Industry would be better off not claiming that it works if they don't know. Observations are very useful, but only after a mathematical module has been developed, tested and linked to the individual observations would we be able to understand and thus talk with knowledge. This knowledge is better not mixed with experience.

The problem

Corrugated board in its simplest form is made from three layers of paper: the inner liner, the fluting and the outer liner. In the first part of the corrugated board manufacturing process the fluting is formed to a periodic wave shape and then glued to the inner liner resulting in the single face. *Figure 2* shows the surface profile of E-flute single face. The next step is to glue the outer liner together with the single face after which it is dried in the hot plate section. It is possible to glue two or three single faces together resulting in double and triple wall board.

The target is to have a flat surface, especially for the outer liner, on which an image is frequently printed. However, often the periodic wave form of the single face is visible in the outer liner. If you look at a flat piece of single face then it resembles a wash-board. If the single face profile is visible in the double backer then this is referred to as »wash-boarding«. We are talking here about a surface profile.

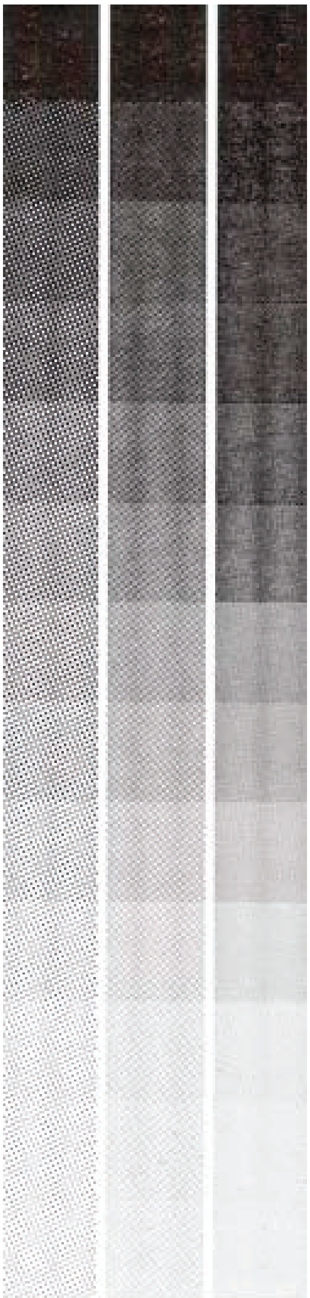


***Figure 1:* The three black bands are printed on 140 g/m² White Top Kraft B-flute board. From left to right the screening of the bands is 12, 20 and 30 l/cm (31, 51 and 76 lpi). Print plate was mounted on foam backing.**

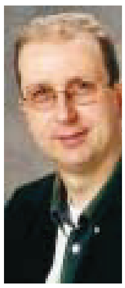
When printed on this board dark stripes are often visible in halftone print areas. The industry commonly refers to wash-boarding when this happens however these are simply stripes in print because we are not looking at the surface profile of the board.

Personally I have often observed stripes in print when the board was perfectly flat thus no visible wash-boarding. It is thus important not to confuse the surface profile description »wash-boarding« of the board with the observation of »stripes« in print. *Figure 3* shows the surface profile of the board on which the print of figure 1 is done. This is B flute board. The recorded surface profile does not show the same periodic curve as expected from the under lying B flute.

To give an indication of the surface profile magnitude of a polymer printing plate the surface of the full tone area of a photopolymer printing plate was scanned (see *figure 4*). The difference in the minimum and the maximum value recorded for the polymer printing plate is similar to that of the scanned surface profile of the corrugated board. There is no sine wave visible in the surface profile of the photopolymer printing plate.

Common known solutions to avoid stripes in printing

The following are descriptions of some common known and used solutions to reduce the stripes in



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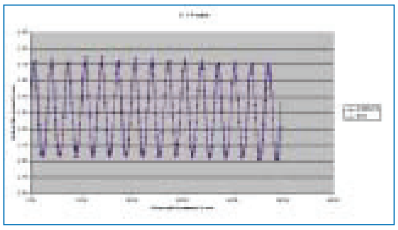

Figure 2: Surface profile of E-flute single face. The difference between minimum and maximum is 1,271µm. The simulated sine curve has a wavelength of 3.3 mm (303 waves/m). Take-up factor for the fluting material: 1.25.

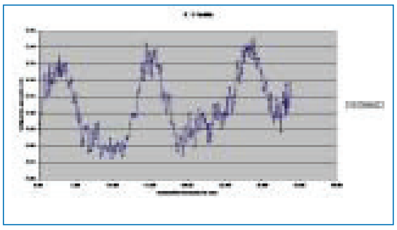

Figure 3: Surface profile of the board used to print the image of figure 1. The difference between minimum and maximum is 70 micron.

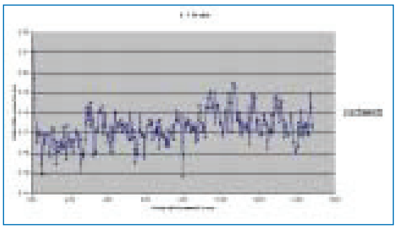

Figure 4: Surface profile of a solid area on a solid photopolymer printing plate. The difference between minimum and maximum is 50 micron.

print on corrugated board.

Backing material

A foam backing material between printing plate and plate cylinder is probably the most common known solution to minimize stripes in print. It is however not likely that the combination of thin polymer material and the use of foam backing will result in a deformation of the polymer material where the deformation of the polymer follows the wash-boarding profile of the corrugated board. It is better to assume that the polymer material is not deforming. How it might work in reality I will explain later. The use of backing material will have an effect on the colour to colour register. Un-equal impression pressure setting will result in a different stretching of the print of different colours in print direction.

Finer fluting thus EF-flute instead of B-flute

The use of shorter wave flutes is also often proposed as a solution to reduce the visibility of stripes. However this solution significantly increases the paper cost of the board. It is claimed that an EF-flute compared to a B-flute of nearly the same total board thickness shows less stripes in printing using a low basis weight outer liner. However one liner and one fluting are added when making EF-flute board compared to B-flute board. The result is an increase of board weight and slower production speed on the corrugator. The board still needs to be dry at the end of the hot plate section but to make EF-flute board nearly the double amount of glue is used compared to B-flute with heavier outside liner. Increasing the basis weight of the outer liner on the B-flute board might also have the desired effect of reducing the visibility of the stripes yet not affecting the speed on the corrugator and still resulting in a lower basis weight board. Today it is difficult to purchase or use White Top Kraft and/or White Top Test liner with a high basis weight (> 200 g/m²) for environmental reasons. Avoiding the use of heavy liners for environmental reasons does not stand-up if customers are supplied with over weight double wall EF-flute board using low basis weight liners.

Coated paper instead of uncoated paper

This option also might result in lower visibility of the stripes in printing. It probably has to do with the way this paper picks-up the ink from the printing plate (shearing of the ink) and that this is possible at lower impression pressure setting. Also the use of a lower ink film thickness on the screen roll will help to reduce the visibility of the stripes.

But how does it work?

The theory

As indicated above it might not be the profile of the surface of the board that gives rise to printed stripes. If we take a closer look at the way dots are printed in a halftone area on top of the flutes and between the flutes (see *figure 5.1* and *5.2*) then it looks as if the same dots printed on top of the flutes show more spreading, filling of the ink than between the flutes.

This points towards the pressure between substrate and print plate being greater on top of the flutes than between flutes. It would explain why also perfectly flat board can show stripes in print. The support of the flutes make the board locally stiffer on top of the flutes then between the flutes. The severity of the stripes in print show would probably better correlate with a force deformation profile of the board then a dimensional surface profile.

The proposed theoretical model to measure the surface force profile of the board and correlate it with the stripes in printing might allow the proposal of a prediction module to determine how severe the stripes might be before printing the board.

This proposed theoretical module also would explain why foam backing material and a finer flute have a positive impact on reducing stripes.

The foam backing material simply reduces the maximum impression force on top of the flute tips so the pressure difference on top of the flutes and between the flutes is reduced yet the printing plate is not deforming following the wash board profile.

Finer flutes means that the force resistance differential between flutes and on top of flutes is reduced.

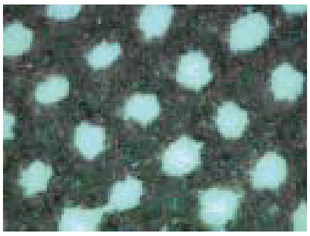

***Figure 5.1:* Image taken from sample of figure 1 in 50% dot area, 30 l/cm (76 lpi) screen, on top of the flutes, at about 200 times magnification.**

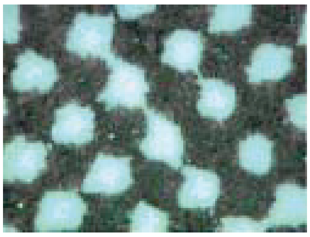

***Figure 5.2:* Image taken from sample of figure 1 in 50% dot area, 30 l/cm (76 lpi) screen, between the flutes, at about 200 times magnification.**

Thus it is most likely the equalisation of the difference in the surface deformation resistance (local E-modules) between flute and on top of the flute will reduce the stripes in printing.

Conclusion

Characterising board and the amount of stripes in print that correlate with the flute profile of the board can probably be best done by making a force surface profile where we measure »the local surface E-module« of the board on top of the flutes and between the flutes. The normal available testing equipment is not sensitive enough to do this. We are talking about measuring low forces (<0.001 N) and small displacements (< 25 micron). *Technology Coaching* is willing to develop, design and build the device that is able to measure this property of corrugated board if any of the readers are interested in it. ■

***Figure 6:* The device used for measuring the surface profile as shown in figure 2, 3 and 4 was developed, designed and built (including software) by Technology Coaching BVBA. Measuring resolution < 4 µm.**