

Filing Ratio Dependence on the Line Thickness Increase at Line-Art Graphics in the Case of Plastic Print Media

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Abstract: *The majority of printing industry standards are concerned with the colour management problems of four-colour printing, while the issue of colour modifications in case of superimposing line-based graphical objects using direct colours has received much less coverage. There are often significant colour distortions resulting from the peculiarities of the design, approval, printing and possible finishing processes associated with line-art graphics. Our research aimed to determine the Filing ratio dependence on the line thickness increase at line-art graphics in the case of plastic print media. We concluded that, in order to get the proper colour effect, the printing order of colours and the vertical or horizontal position of security graphic elements on the sheet must definitely be specified during the design process.*

Keywords: *line art reproduction, line thickness, filling ratio*

1 Introduction

Printed matter that is protected against counterfeiting contains, as visual elements, characteristic patterns consisting of a complex system of delicate, thin lines (*Figure 1*). This is the so-called guilloche pattern, which is special graphics made up of complex shapes and very subtle lines with varying line thickness, which cannot be reproduced in good quality using photocopying or other conventional techniques (Eiler, 2007).

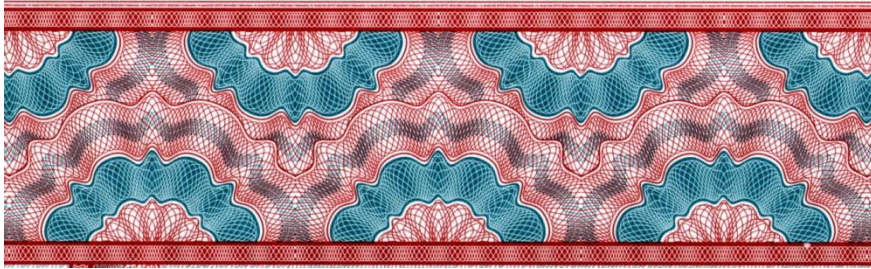


Figure 1

Two-colour Guilloche pattern

The shape and dimensions of mathematically determined, periodic function patterns are today developed using computer-based design software. (Giotto, 2009) When guilloches are used in printing lines colour should be solid for process or spot colors (one color from CMYK or PANTONE®). For example, when 60%C, 30%M, 20%K are used register problems can arise (out of register or superimposition problems). We do not recommend modifying lines width as this can result in changing style of an image or lead to distortions. Images lines have variable width.

Approval of security graphics is also implemented through digital proofs before printing, just like other printed products today. Digital proof procedures do not use these direct colours, which makes the accurate colour reproduction of guilloche patterns more difficult. Although today's proof devices are able to make prints in 12 colours, which results in a significant improvement in terms of the rendition of direct colours, the proof printer must be calibrated to the relevant printing conditions to ensure conformity with the printing process. (ColorAcademy, 2006)

2 The Objectives of the Research

Technical literature and the majority of printing industry standards are concerned with the colour management problems of four-colour printing, while the issue of colour modifications in case of superimposing line-based graphical objects using direct colours has received much less coverage. (Pekaricova *et al.*, 2009) Because of the lack of research findings on the subject, major problems arise in line-art printing as well, where the guilloche pattern is created by printing direct-colour line-based graphical objects next to and on top of one another. There is often significant colour distortion resulting from the peculiarities of the design, approval, printing and possible finishing processes associated with guilloche patterns. (Novotny *et al.*, 2011) The overall colour effect of the finished product may differ from what the customer expected, or from the approved graphic design or proof. In such patterns, colour effect differences are due to a number of reasons.

Some of these are technological issues, e.g. the fact that the digital proof used for design purposes and the printing procedure are based on different principles. The colorimetric properties of inks also vary, and the surface and colorimetric properties of the base materials used may also be different. In addition, changes to the sequence of colours being printed may also lead to deviations in colour. Furthermore at the second or further print runs of securities is also essential to apply the first run's setting because the overall colour effect can be change and it can cause problem with costumers. (Malacara, 2002)

3 Test Printing

In order to be able to analyze changes in line thickness, we included in the test form a sequence of five line grids using lines with a thickness of 30, 50, 70, 90, 110 μm and a filling ratio of 10, 25 and 50%. (Figure 2)



Figure 2
Test chart for lines

We made digital proofs based on the test form using an Epson Stylus Pro 7880 proof printer. We prepared the print on two of the plastic materials, which varied widely in terms of their type and printability.

Basic materials:

PVC core foil (Klökner, 310 μm)

Tyvek foil (DuPont, 75 gr/m^2)

The examined colour pairs were:

P284 Blue – P727 Ocher

P346 Green – P021 Orange

P128 Yellow – P211 Rose

P1785 Red – P429 Grey

The printing process was performed on a Heidelberg Speedmaster SM 52-4+L UV-curing sheet-fed offset press with Schneemann Supra UV inks, and under standard operating conditions.

4 Measurements and Evaluation of the Results

The prints (*Figure 3*) and proofs were examined not only instrumental measurements, but also visual comparison, the most important aspect for the customer being the conformity of the finished product with the overall effect he deemed acceptable according to his original design and the proof that has been presented to him and approved by him.

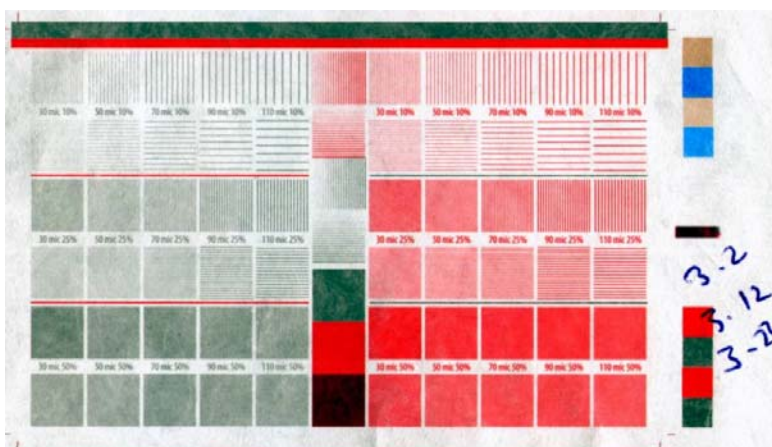


Figure 3
Printed test of red–grey pair on Tyvek foil

4.1 Line Thickness and Filling Ratio Changes

For examination of the line thickness of test prints we used Mitutoyo Absolute Digimatic built-in calliper ruler, and Mitutoyo precision measuring magnifier. Based on our measurements we realised that the line thickness increase depends on the line vertical or horizontal position (to printing run direction) significantly. We observed 20-60 μm increase in thickness at the vertical lines depending on original line thickness and printed media. At the horizontal lines the average value of increase was smaller, 20 μm . The proof also showed a difference to the original value.

The effect of the line thickness increase can be observed at the results of filling ratio examination. The fields of vertical lines differ from fields of horizontal lines in increasing of filling ratio significantly. For example the next diagrams (*Figure 4-6*) show the results at red colour.

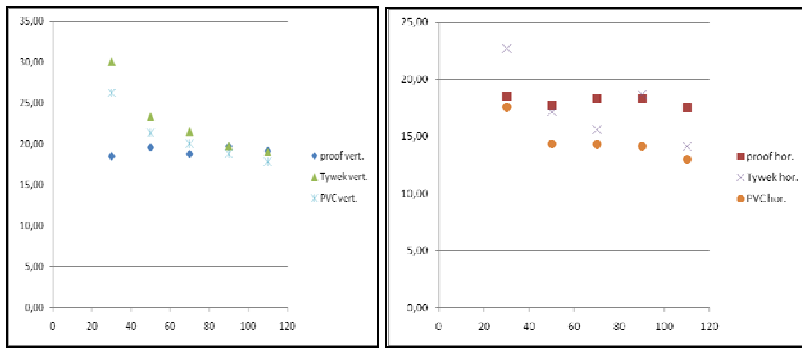


Figure 4

Increase in filling ratio at 10% in the case of different print media and proof (vertical and horizontal lines with thickness of 30, 50, 70, 90, 110 μm)

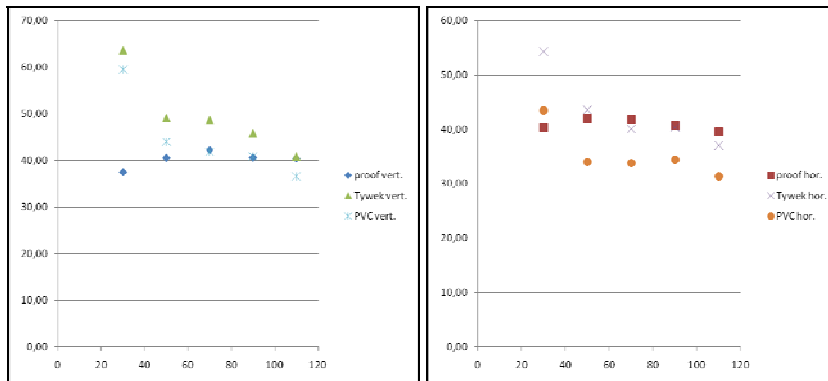


Figure 5

Increase in filling ratio at 25% in the case of different print media and proof (vertical and horizontal lines with thickness of 30, 50, 70, 90, 110 μm)

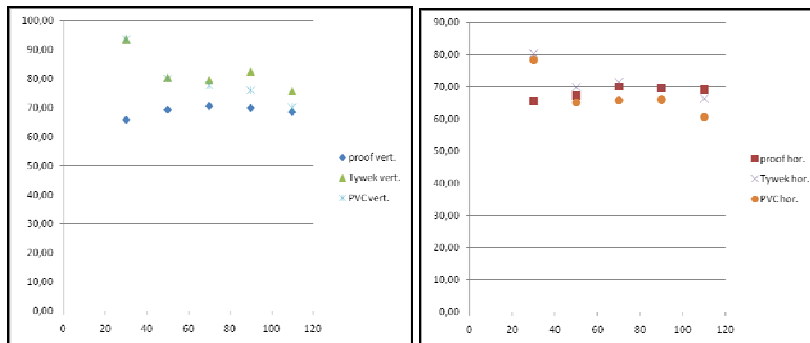


Figure 6

Increase in filling ratio at 50% in the case of different print media and proof (vertical and horizontal lines with thickness of 30, 50, 70, 90, 110 μm)

All in all, the smallest line thickness variation in comparison with the original value was seen with ochre lines, taking into consideration all reviewed colours. The colour showing the largest variation, on the other hand, was green and red.

Based on our analysis of line thickness, and filling ratio changes, we concluded that PVC core foil and proof were characterized by the lowest amount of line distortion), while the largest differences were seen on Tyvek special plastic foil. On this printing medium, lines with a thickness of 30 μm are intermittent and the thickest. The images, printed on this surfaces, and the PVC core foil are uneven, line edges are wavy (*Figure 7*).

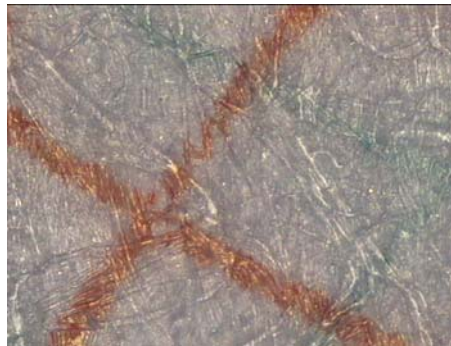


Figure 7

Video-microscopical picture on Tyvek

Conclusion

Because of the line-art graphics is created by printing direct-colour line-based graphical objects next to and on top of one another there are often significant colour distortions resulting from the special design, approval, printing method.

Examining the changes in line thickness, we concluded that, in order to get the proper colour effect, the printing order of colours and the vertical or horizontal position of security graphic elements on the sheet must definitely be specified during the design process. Changes in line thickness, also led to variations in the overall colour effect. Because the customer accepts the proof as a prototype, colour differences and increases in line thickness both need to be kept within certain limits. We can simulate the colour modifying effect of the printing process at proof making. The simulation should be performed for all colours and basic material, frequently ordered by customers. This method results in costs for the printing company but is still less costly than individual proof printing in the press room or the possible consequences of customer complaints.

We gave special importance to this issue as we wish to know to what extent the reproduction process results in colour effect differences. Our findings may contain useful information for the design of guilloche patterns and for the approval of the same.

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