

Quality of the Line Reproduction on Environmentally Friendly Pressure Sensitive Labels Facestock

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Abstract

Pressure Sensitive Labels (PSLs) can be found on the wide range of products, from food items and beverages to perfumes and other household products. Given their prevalence, there is a clear initiative to reduce the proportion of synthetic polymer facestock in favor of biodegradable materials. The design of PSL is becoming more and more attractive, so it is necessary to examine the quality of the printed line on biodegradable facestock materials, and to investigate whether an equal amount of applied ink gives a satisfactory result as on synthetic polymers which are commonly used. Yellow ink lines of various widths and orientations were printed on seven different commercially available PSLs, three of which are fiber based with high content of recycled paper and agro-industrial by products. Study showed that the lines printed on environmentally friendly PSLs can compete in quality (width, raggedness, blurriness, contrast, fill and darkness) with those printed on polyethylene.

Key words

Pressure Sensitive Labels, Line Quality, Sustainable Printing

1. INTRODUCTION

Today's label market is one of the most represented branches of the press, which will certainly continue to grow in the years to come. The label represents the first contact of a potential buyer with the offered product. Precisely because of that, label has no longer just an informative role, but its goal is to make a difference with its design and appearance when choosing a product. Previous research has mainly focused on the possibility of replacing classic synthetic polymer labels with biodegradable ones [1], while our research will focus on the possibility of printing details on biodegradable substrates, as well as their comparison with prints generated on commercial synthetic polymers.

The way millennials choose the products is significantly different from the way previous generations have done it. Elliot et al. [2] have determined on the example of wine bottle selection that millennials choose non traditional products whose design is characterized by bright colors and non standard layout with modern typeface. At the same time, millennials are much more environmentally aware than previous generations and choose sustainable products when they have the opportunity [3], [4].

Precisely because of that, if we want an attractive label design with clearly defined details, it is necessary to examine the possibility of printing on environmentally friendly labels, and to investigate whether it is possible to get the same quality print as in the case of commercially available polyethylene. There are visual attributes that describe image quality of offset prints like micro-uniformity, macro-uniformity, color rendition, text and line quality, gloss, sharpness, and spatial adjacency or temporal adjacency attributes [5].

Line quality is defined according to its width, raggedness, blurriness, contrast and fill within ISO13660 norm [6]. Line width measurement is carried out through reflectance measurement. If the reflectance of the paper substrate

is R_{max} , reflectance of the print is R_{min} , counters of the line profile of the edge is defined as the point of 60% transition between R_{max} and R_{min} according to equation:

$$R_{60} = R_{max} - 0.6 \cdot (R_{max} - R_{min}) \quad (1)$$

Raggedness is defined as the geometric distortion of an edge from its ideal position. It is measured as the standard deviation of the residuals from a line fitted to the edge threshold of the line under study, calculated perpendicular to the fitted line.

Blurriness measures the average distance between the inner and outer boundary edges. It is defined in the standard as the distance between the R_{10} and R_{90} thresholds.

Contrast is defined as the relationship between the darkness of a line segment and its field and it is calculated according to

$$contrast = \frac{R_{field} - R_{image}}{R_{field}} \quad (2)$$

Where R_{field} stands for mean reflectance factor of the surrounding field (paper substrate) and R_{image} denotes mean reflectance factor within the inner boundary edge of the line.

Fill is the appearance of homogeneity of darkness within the boundary of a line segment. It is obtained as a ratio of the area with 75% relative reflectance value or more within the inner boundary to the total area within the inner boundary.

2. MATERIALS AND METHODS

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2.1. Properties of the Pressure Sensitive Labels used in the study

Seven different pressure sensitive label (PSL) materials commercially available on the market were used in the study due to their various facestock characteristics (paper/film). Four PSLs have a fiber based facestock, two filmic materials comprise of bio-based polymers as facestock, while the remaining one is conventional synthetic material (Table 1).

Table 1. Properties of used PSL given by the manufacturer [7]–[11]

Substrate grade	Abbreviation	Facestock		Liner		Total laminate
		Basis weight ISO 536, g/m ²	Caliper ISO 534, μ m	Basis weight ISO 536, g/m ²	Caliper ISO 534, μ m	Caliper ISO 534, μ m
Fasson ® rCRUSH BARLEY FSC S2030-BG45WH FSC	B	90	110	70	61	190 ±10%
Fasson ® rCRUSH GRAPE FSC S2047N-BG45WH IMP FSC	G	90	114	70	61	192 ±10%
Fasson ® rCRUSH CITRUS FSC S2030-BG45WH FSC	C	100	130	70	61	210 ±10%
Fasson ® PE85 BIOB CLEAR S692N- BG40WH FSC	PEC	78	82	59	53	152 ±10%
Fasson ® PE85 BIOB WHITE S692N- BG40WH FSC	PEW	82	82	59	53	152 ±10%
Fasson ® THERMAL TOP K8 FSC R5100-BG40BR	TT	76	82	55	47	147±10%
Fasson ® 772 BRUSHED CHROME S697-HF125	CH	70	51	126	126	196±10%

Fiber based facestock of PSL used in this research are produced with 15% agro-industrial byproducts (grape fibers obtained from wine making processes, citrus fibers collected from citrus mash after juice production, and barley fibers from brewing beer and malt whiskey), 40% post-consumer recycled paper and 45% virgin wood pulp in order to form a high-quality natural paper [9]–[11]. Bio-based polymers facestock is made mostly from sugar cane ethanol, certified under the Bonsucro® scheme, which is converted in a similar way to conventional polyethylene (PE), and available in white and clear performance [12]. Facestock of thermal top is white woodfree, top coated thermal paper [13], while chrome has a conventional filmic facestock [14]

Adhesives used with paper laminates are permanent adhesives, both emulsion acrylic and rubber based. The glassine liners used in this research are FSC certified, fossil-free and recyclable. Glassine liner used with recycled content fiber based PSL materials is white, supercalendered glassine paper, with basis weight of 70 g/m² and thickness of 61 μ m. Glassine liner used with filmic recycled content PSL materials is white, supercalendered glassine paper, with basis weight of 59 g/m² and thickness of 53 μ m. As for glassine liner used with woodfree, top coated thermal paper based PSL material, it is brown, supercalendered glassine paper with basis weight of 55 g/m² and thickness of 47 μ m, while the glassine liner used with conventional filmic facestock is one-side coated, bleached kraft paper with basis weight of 126 g/m² and thickness of 126 μ m.

2.2. Printing process

Prints were generated with yellow UV offset ink on commercial offset machine for label printing. Vertical lines (0.5 pt and 1 pt nominal width) in the machine direction, and horizontal lines (0.1 pt and 0.7 pt nominal width) perpendicular to the direction of printing process were obtained on all seven substrates.

2.3. Image analysis

Quantitative analysis of the horizontal and vertical printed line samples was conducted with PIAS II (Personal Image Analysis System). It consists of a measurement head housing a high performance digital camera and an optical modules. The operating principle of PIAS is discussed in following articles[15]–[17]. The standard optical arrangement is 45/0 geometry, typical for reflective, densitometric measurements. PIAS software has a built in ISO13660 norm regarding the quality of the line reproduction. The results are displayed in both numerical and graphical form. The user can display contours, bounding boxes, center marks, and ROIs for the image features analyzed. Length of the line for raggedness measurement was 15 mm.

3. RESULTS AND DISCUSSION

Pictures of the selected horizontal and vertical lines are given in Figure 1. All of the pictures were rotated and aligned parallel to each other for easier visual analysis. Differences in the print appearance and line width are clearly noticeable and expressed. This can primarily be explained by different optical (brightness, colour, opacity, gloss) and mechanical (weight, thickness, density, two-sidedness, smoothness, permeability, rigidity, roughness, porosity) properties of the facestock substrate. All paragraphs must be justified, i.e. both left-justified and right-justified.

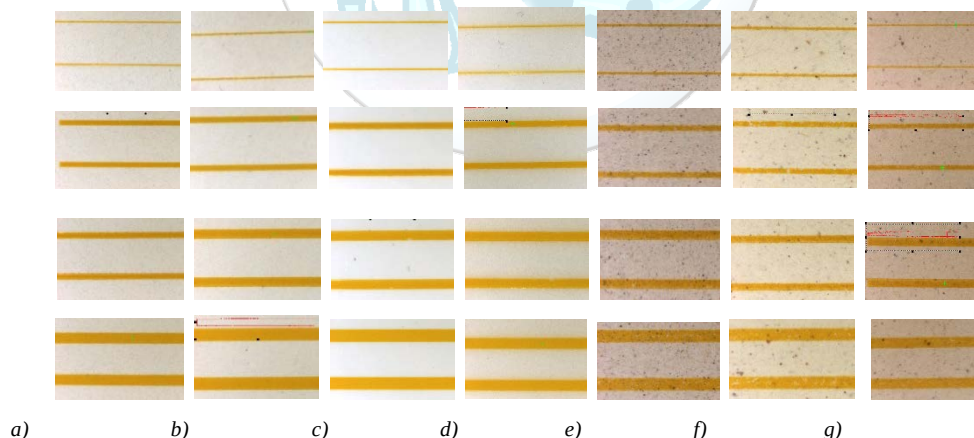


Figure 1. Printed lines on a) CH, b) TT, c) PEW, d) PEC, e) G, f) C, g) B
(top to bottom: nominal line width 0.1 pt, 0.5 pt, 0.7 pt, 1 pt)

Numerical data of measured line width depending on nominal line width are given in Figure 2. Prints made on polyethylene white (PEW) facestock show the highest reproducibility related to line width; they are closest to the nominal values regardless of their value in prepress.

Prints generated on polyethylene clear (PEC) facestock show a slightly higher values for 0.1 pt, 0.5 and 0.7 pt lines of nominal width and infinitesimal decrease when it comes to 1 pt line. Lines printed on fiber based facestock (C, G, B) show higher deviations compared to polymer based facestock although there are significant differences

between them. For the 0.1 pt line width printed on barley facestock the measured line width is the closest to the nominal, while the lines generated on grape and citrus based facestock are almost twice as wide.

On the other hand, all three paper based facestocks showed the same level of deviation (drop of 20 %) from the nominal for 0.5 pt line. For the 0.7 pt lines, barley again stands out as a paper based facestock that can be competitive, in terms of line width reproduction to polyethylene.

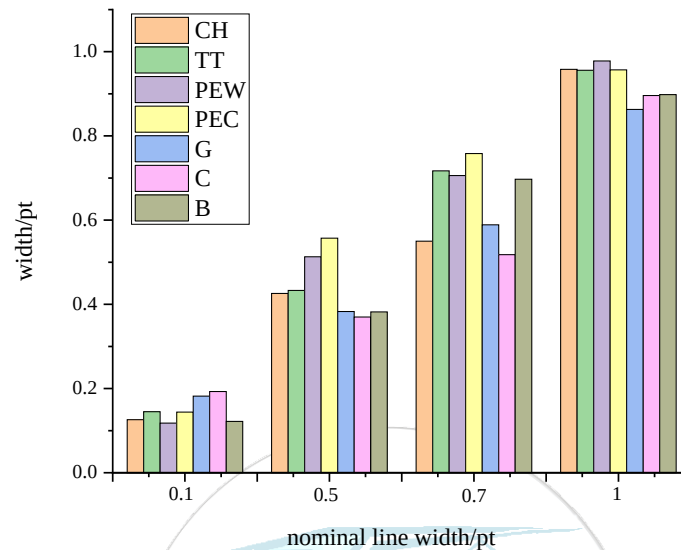


Figure 2. Dependence of measured line width on nominal line width for all seven substrates

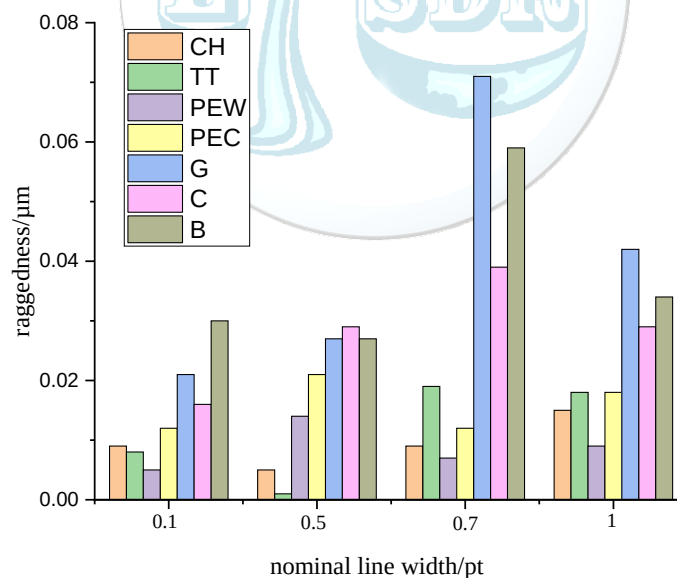


Figure 3. Dependence of measured line raggedness on nominal line width for all seven substrates

Grape and citrus based facestock show a much lower line width. If we take into account the direction of printing, vertical lines (0.5 pt and 1 pt nominal width) showed consistent width reduction for paper based facestock (0.120 ± 0.007) pt regardless of the nominal line width. Horizontal lines (0.1 pt and 0.7 pt), on the other hand, due to the fiber structure within the substrate show significantly larger deviations within the paper based facestock for citrus

and grape based PSLs, while horizontal lines, as a rule, show line width increase, while the vertical lines widths are reduced.

Since raggedness is related to the ink penetration and bleeding which are controlled by the fiber direction within the substrate it is not surprising that lines printed on citrus, grape and barley based facestock show a higher degree of raggedness (Figure 3). Also, in comparison to white woodfree, top coated thermal paper (TT) facestock made from agroindustrial waste shows significantly higher raggedness values. If we consider the influence of the direction of printing, horizontal lines (0.1 pt and 0.7 pt nominal width) have higher raggedness levels. Lowest raggedness, regardless of the dimensions of line width can be assigned to polyethylene white facestock. It is interesting to compare raggedness values for two filmic facestocks, chrome and polyethylene white. Namely, polyethylene white facestock is of superior quality.

Polyethylene clear based facestock stands out with the highest level of blurriness (0.43-0.75 μm) (Fig. 4). On the other hand, other bio-based polymer facestock (PEW) shows the lowest blurriness value of 0.15 μm and the highest of 0.3 μm . If we compare the line blurriness generated on lines printed on paper based facestock it can be seen that TT shows the lowest raggedness values (0.05-0.15 μm) while citrus, grape and barley range from 0.18-0.4 μm for citrus based facestock, 0.2-0.75 μm for grape based pressure sensitive label facestock and 0.28-0.6 μm for barley based facestock. Line blurriness for prints generated on commercial filmic facestock (CH) has the smallest deviations 0.15-0.25 μm .

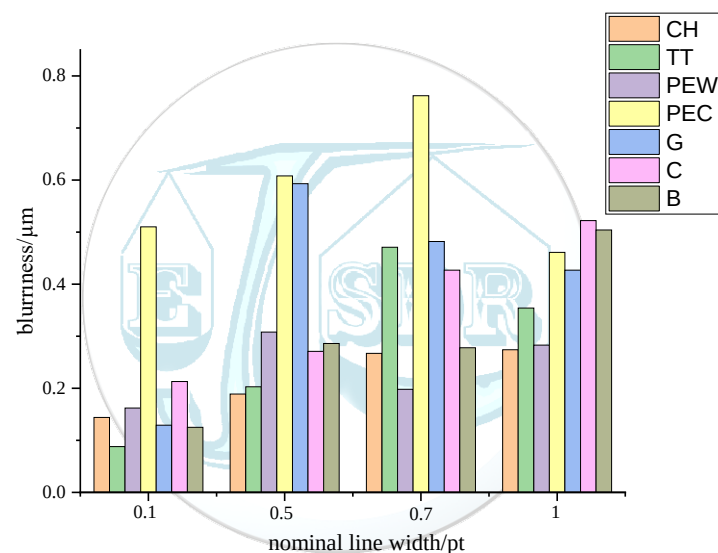


Figure 4. Dependence of measured line blurriness on nominal line width for all seven substrates

From fig. 5 it can be seen that the line contrast is the lowest for the thinnest line (0.1 pt) with the min value of 0.15 for prints made on barley based facestock. For all samples, lines printed on polyethylene clear PSL facestock show the lowest contrast values due to its clear performance which directly affects the contrast measurements. Line contrast is similar for 0.5, 0.7 and 1 pt nominal line widths and ranges in values from 0.25 to 0.35. The color of the liner material affects the overall appearance of the print and consequently contrast measurements. In this regard, it might be more reliable if all labels were affixed to the same substrate material during the contrast measurements. Since most of the PSL facestock substrates are used in the study are yellowish, the choice of printing yellow lines is more than justified because our goal was to examine the limit values of line widths that can be printed on given substrates, while maintaining reproducibility which is crucial for attractive detailed design.

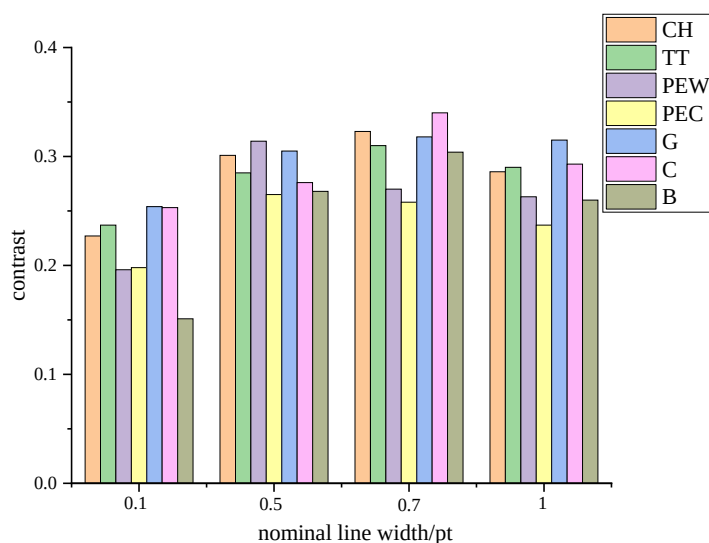


Figure 5. Dependence of measured line contrast on nominal line width

4. CONCLUSION

The aim of the study was to examine the quality of the line reproduction on environmentally friendly pressure sensitive labels facestock. PSL materials are dedicated for labelling of primary labels used on high and premium goods with a natural appearance e.g., wine, spirits, specialist foods. Yellow ink lines (UV offset ink) of various widths and orientations (0.1 pt, 0.7 pt-horizontal lines, 0.5pt, 1 pt-vertical lines) were printed on seven different PSL facestocks (four fiber based, three filmic). Three fiber based facestock of PSL used in this research are produced with 15% agro-industrial byproducts (grape fibers obtained from wine making processes, citrus fibers collected from citrus mash after juice production, and barley fibers from brewing beer and malt whiskey), 40% post-consumer recycled paper and 45% virgin wood pulp in order to form a high-quality natural paper, while the remaining one is made from white woodfree, top coated thermal paper. Two bio-based filmic polymer facestocks are made mostly from sugar cane ethanol, while remaining one is conventional polyethylene.

Study showed that the lines printed on environmentally friendly PSLs can compete in quality (width, raggedness, blurriness, contrast) with those printed on conventional polyethylene. Bio based polyethylene (PEW) facestock shows the highest reproducibility related to line width. Facestock made from barley stands out as a paper based facestock that can be competitive, in terms of line width reproduction to synthetic based polyethylene facestock. Further research will aim to examine the possibility of protecting the print on environmentally friendly labels in order to prolong its shelf life.

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CONFLICT OF INTEREST STATEMENT

“The author(s) declare(s) that there is no conflict of interest”.

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