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Evaluation of the Line and Edge Quality of Printed Letters on Recycled Paper with Straw Pulp

Maja Rudolf, Irena Bates, Ivana Plazonić, Valentina Radić Seleš, Katja Petric Maretić, Marija Magdalena Mendeš
University of Zagreb, Faculty of Graphic Arts, Zagreb, Croatia

Introduction

The use of papers with alternative sources of cellulose pulp has been widely explored in the recent past, using non-wood, sustainable and renewable materials derived from different types of plants. Cereal straw is interesting for paper production because it has a similar cellulose content to wood, and a lower lignin content, it is cheap and renewable resource compatible with the high demand for paper as packaging and printing medium. Extensive research has shown that cereal straw is a valuable raw material for the paper industry. The type of substrate has a significant impact on the quality of the printed text suggesting that a higher contrast between text and paper and larger text size can contribute to good legibility.

Problem Description

This research focuses on evaluating the quality of ink-jet printed text patterns for two common typefaces Arial and Times New Roman on paper substrates made in the laboratory conditions containing recycled newsprint pulp and 30% of wheat, barley or triticale pulp. Parameters used in assessing the quality of line reproduction, such as barcode lines, can be used to evaluate the quality of printed text, namely: blurriness and raggedness as characteristics of line edges, and fill and contrast as parameters of reproduction quality.

Methods

The collected straw from three cereals was manually cut and converted into a semi-chemical pulp according to the soda method in an autoclave at temperature of 120 °C, 10:1 liquid to biomass ratio and an alkali level of 16% for a period of 60 minutes. Cereal pulps were added to the recycled newsprint pulp **N** at a weight ratio of 7 : 3 (newsprint pulp: cereal straw pulp). Paper substrate with added wheat pulp was marked as **3NW**, **3NB** was a abbreviation used for paper with added barley pulp, and paper containing triticale pulp was marked as **3NTR**. Recycled newsprint pulp was obtained from the commercial paper **K**, which is made from recycled wood pulp used for printing daily newspapers. In the laboratory paper substrate production phase, four different types of samples were produced using the Rapid Köthen sheet former following the standard ISO 5269-2:2004.
The next phase included digital printing of the letter pattern which consisted of one uppercase and one lowercase letter "A" in the standard size of 12 pt in two common typefaces – Arial and Times New Roman. The pattern was printed with black UV curable ink using the digital printing technique by AGFA, Anapurna M1600 printing machine.
Print quality analysis was based on measurements of fill, contrast, blurriness, and raggedness of the line edges according to the standard ISO 13660 using a PIAS-II (Personal Image Analysis System) digital microscope and its associated software.

Image quality was assessed according to the parameters blurriness, raggedness, fill and contrast described in standard ISO 13660. Blurriness represents the transition between the printed area and the paper. Raggedness is a property that defines the roughness of the printed line edge. Fill is defined as the apparent uniformity of darkness within the boundary of the line. Contrast is the relationship between the darkness of the printed area and its field (printing substrate, i.e. paper).

Results

Table 1 *3D surface plot diagrams of printed letters on commercial and laboratory paper substrates*

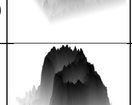
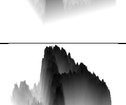
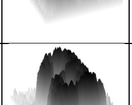
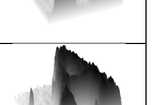
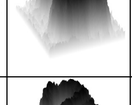
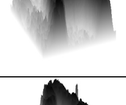
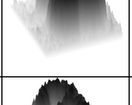
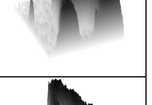
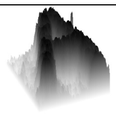
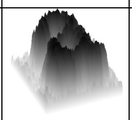
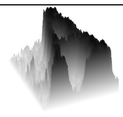
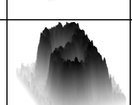
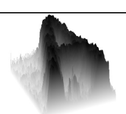
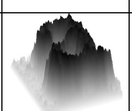
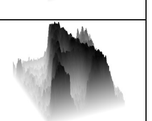
Paper substrate	Arial		Times New Roman	
	lowercase	uppercase	lowercase	uppercase
K (commercial newsprint)				
N (laboratory newsprint)				
3NW (newsprint + wheat)				
3NB (newsprint + barley)				
3NTR (newsprint + triticale)				

Table 1 shows that the printed surface of the letters is non-uniform but the significant difference between commercially and laboratory produced papers was not observed. A visual examination shows that letters printed in the Arial typeface have a slightly better uniformity of print with less protrusion peaks than the Times New Roman.
Laboratory produced papers had smaller or no difference between fill parameter for Arial and Times New Roman typefaces, regardless of the type of straw pulp (Table 2). The contrast between the printed letter and the surrounding background, also showed largest values for the Arial typeface on all printing substrates.

Table 2 *Average measured values and standard deviations of fill and contrast for all printing substates and typefaces*

Printing substrate / typeface			Fill	Contrast
K	Arial	avg	**0.97**	**0.95**
		stdev	0.08	0.05
	Times New Roman	avg	**0.94**	**0.91**
		stdev	0.09	0.06
N	Arial	avg	**0.96**	**0.92**
		stdev	0.09	0.06
	Times New Roman	avg	**0.95**	**0.89**
		stdev	0.09	0.06
3NW	Arial	avg	**0.97**	**0.92**
		stdev	0.06	0.04
	Times New Roman	avg	**0.96**	**0.89**
		stdev	0.08	0.05
3NB	Arial	avg	**0.96**	**0.91**
		stdev	0.07	0.04
	Times New Roman	avg	**0.96**	**0.89**
		stdev	0.09	0.06
3NTR	Arial	avg	**0.97**	**0.90**
		stdev	0.07	0.04
	Times New Roman	avg	**0.95**	**0.88**
		stdev	0.09	0.05

In Figure 1, the unprocessed surface of the laboratory produced paper substrates results in a slightly higher blurriness of the letter edges than commercial paper (K). The paper substrates with added straw pulp (3NW, 3NB, 3NTR) showed no significant difference compared to the laboratory paper substrate without added straw pulp (N). Comparing the two typefaces, Arial and Times New Roman, the prints on laboratory papers show slightly lower blurriness on Times New Roman but without significant value, while commercial paper shows a lower blurriness on Arial.

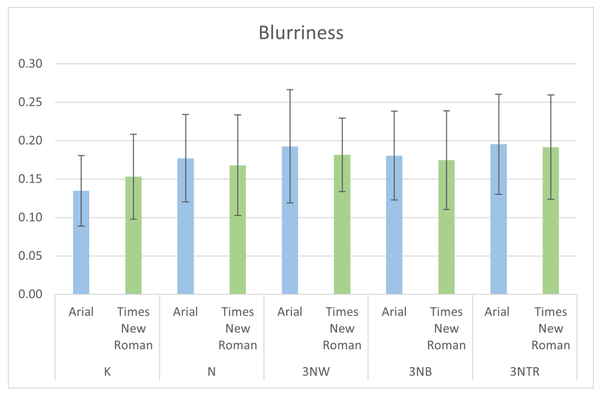


Figure 1 *Comparison of blurriness values of letters printed in Arial and Times New Roman on all paper substrates*

Value of raggedness had no correlation with the printing substrate or the means of production (Figure 2). The highest raggedness was measured on papers with barley pulp for both typefaces, and the lowest values showed on papers with triticale. The prints on the papers with the addition of wheat straw measured similar values as the control and reference paper substrates K and N, which were produced from recycled wood pulp only.

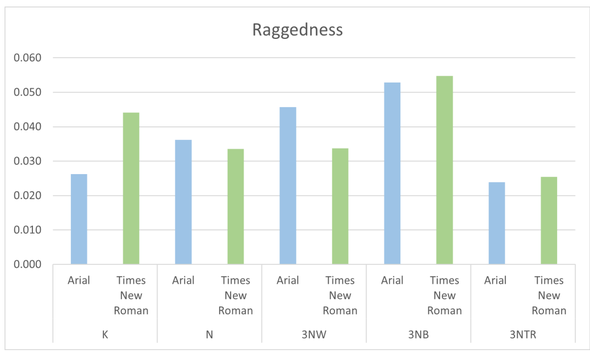


Figure 2 *Comparison of raggedness values of letters printed in Arial and Times New Roman on all paper substrates*

Conclusion

Commercially and laboratory produced papers with and without addition of straw pulp show similar results in edge blurriness, with slightly but insignificantly higher values for papers with the addition of straw pulp.
Raggedness show less consistency; the lowest values were determined for papers containing triticale pulp, and the highest values for papers with barley pulp. Papers with wheat pulp showed similar values as commercially and laboratory produced papers without added straw pulp.
Fill and contrast measurements were similar in laboratory produced papers regardless of the paper substrate composition, with values greater for the Arial sans-serif typeface than for the Times New Roman serif typeface.

ACKNOWLEDGMENTS

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