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Session D: Biomass and sustainability

THE RUB RESISTANCE OF PRINTED PAPERS WITH VARIABLE CONTENT OF WHEAT PULP

Ivana Plazonic, Zeljka Barbaric-Mikocevic, Vesna Dzimbeg-Malcic, Irena Bates*
University of Zagreb, Faculty of Graphic Arts, Getaldiceva 2, 10 000 Zagreb,
** ivana.plazonic@grf.hr*

Introduction

Printing is widely used in our society to pass on information especially by newspaper publications on a daily basis. The main printing process for printing newspapers in western Europe is coldest web offset at a very fast rate. The most important pigment in coldest printing is black colour, which is drying by absorption (penetration into paper substrate i.e. newsprint). Because newsprint is not heated, that allows little time for the ink to air-dry. The ink is absorbed by the inner fibers of the sheet of paper and remains there a bit damp during most of the transient life of the paper (the vehicle doesn't completely evaporate) [1]. So, it is very common for newspaper readers to have black fingers by the time they reading the newspaper. Namely, it is a consequence of the black ink rubbed off the newsprint and the amount depends on how fresh the newspapers are. Undoubtedly on the newspaper print quality influence the paper substrate as well. The printing substrate with a low abrasion resistance may suffer a significant decrease in product appearance and readability of printed information. Newsprint intended for the printing of newspapers is a relatively inexpensive uncoated low-grade paper. It could be made of different pulps, especially deinked pulp or virgin mechanical pulps. Newsprint made from mechanical pulp have high lignin content, while newsprint samples made from recycled paper have low values of lignin because during recycling they had been mixed with fibres from higher-grade paper to increase the strength of the paper. This addition of longer fibres during recycling process is necessary because after five to seven cycles of recycling process the fibres become too short for producing new paper. Regardless of the origin of the fibres and pulp in the composition of newsprint its characteristic is a low brightness. The aim of this research was to explore the reproduction quality of printed laboratory papers made of variable content of wheat pulp. Wheat straw is chosen as agricultural residue and renewable natural resources of virgin cellulose. The reproduction quality of printed laboratory papers was observed through rub resistance analysis. The rub resistance of printed laboratory papers was determined 6 and 24h after printing.

Materials and Methods

In this research laboratory made straw-containing papers were used. For that purpose winter types of wheat straw was converted to a semi chemical pulp according to the Soda method. The conversion of straw into pulp was done by pulping process involving chemical treatment to remove part of the lignocelluloses fiber-bonding material and mechanical refining to complete the pulping action [2, 3]. Pulping conditions are presented in Table 1.

Table 1: Extraction Conditions during Pulping

Types of straw	Pulping method	Extraction conditions
Wheat	Soda pulping	Temperature of 120 °C, alkali level of 16% for 60 min, and a 10:1 liquid to biomass ratio

After thermal treatment under controlled and defined extraction conditions, the pulp slurry was removed from the black process liquor by decantation and rinsed with water. In a Valley beater (Techlab Systems (TLS), Spain), pulp was diluted with tap water to maintain the pulp suspension at a 1.5% consistency and fiberized at pH 9, 24 °C, and 500 rpm for 40 min. Finally, the pulp was drained by Manual Sheet Former TAPPI (Techlab Systems (TLS), Spain) and allowed to dry to a moisture content of ca. 7% at room temperature. Obtained unbleached wheat pulp was mixed with recycled newsprint in different weight ratios (0:100, 10:90, 20:80 and 30:70) for forming laboratory papers using a Rapid Köthen Sheet Machine (Frank–PTI GmbH, Birkenau, Germany) needed for this research (Fig.1). Commercial UPM News C paper was used as a basic component to which was added wheat pulp [3, 4]. Altogether, three paper sheets (42.5 g/m^2, 20 cm diameter) with variable content of wheat pulp and a control sheet were formed.

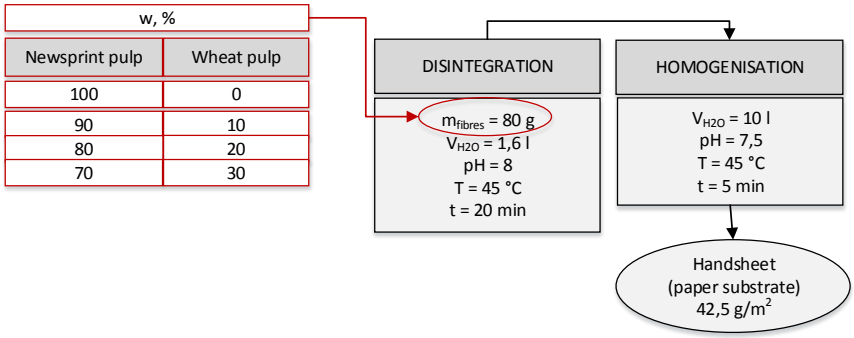

Figure 1: Workflow of laboratory paper production

In Table 2 some characteristic of formed laboratory papers are presented [3].

Table 2. Unprinted Laboratory Papers Properties

Laboratory Papers		Thickness (µm)	Brightness (%)	Ash (%)	Bekk smoothness (sek)	
					felt side	wire side
straw pulp	0	94.0 ± 2.79	58.59 ± 0.43	4.73 ± 0.22	16.70 ± 2.67	8.86 ± 0.51
wheat	10	95.3 ± 2.83	53.36 ± 0.50	4.14 ± 0.43	15.06 ± 1.94	8.78 ± 0.68
	20	98.1 ± 5.28	49.62 ± 0.38	3.77 ± 0.31	14.86 ± 1.35	8.54 ± 0.78
	30	101.5 ± 5.32	45.81 ± 0.42	3.64 ± 0.07	14.30 ± 1.22	9.34 ± 0.58

The laboratory printing was carried out on Prufbau Printability Testing Machine (Fig.2).

Figure 2: Prüfbau laboratory printing process, which simulates offset printing process

In the printings, a carbon black ink, which is generally used for newsprint in a coldset, offset process was used. The ink dosage of 2.00 cm^3 was distributed evenly over the printing cylinder and the ink was transferred to the laboratory paper samples with a width of 40 mm, an applied load of 150 N cm^{-3} and a speed of 1 m/s. In this way, all samples were printed in

full-tone black and dried naturally. To observe the reproduction quality of the printed papers the rub resistance was determined. Since the time interval between the printing process and the testing of resistance to rubbing strongly affect the results, testing was performed 6 and 24 hours after printing. Drying time of 24 hours is in accordance with the recommendations of the World Association of Newspaper Publishers (WAN-IFRA), while the time of 6 hours was selected with regard to newspapers distribution to market. The rub resistance of prints was provided in accordance with BS 3110:1959 standard [5] by Rub and Abrasion tester (Hanatek, UK). Entire contact surface of prints were evenly rubbed on the principle of circular movement with white uncoated paper (Arcoprint 110 g m^{-2}, manufactured by Fedrigoni, UK) at a pressure of 107.15 Pa, which is determined by the mass and number of 10 rpm. Rub resistance of the printed papers was defined based on optical properties of the prints (L*, C* and h* colour parameters), which were computed in accordance with the TAPPI Standard (T524-om-02). Where L* represented the lightness (from 0 to 100), C* represented chroma or relative saturation and h* represented hue angle of the colours in the CIELab colour space. The Euclidean colour difference (ΔE_{00}*) of all analysed prints were calculated with the following equation [6], using the corresponding starting material (unrubbed print) as reference:

$$\Delta E_{00}^{*} = \left(\frac{\Delta L^{'}}{k_L S_L}\right)^2 + \left(\frac{\Delta C^{'}}{k_C S_C}\right)^2 + \left(\frac{\Delta H^{'}}{k_H S_H}\right)^2 + R_T \frac{\Delta C^{'}}{k_C S_C}\frac{\Delta H^{'}}{k_H S_H} \quad (1)$$

Results and discussion

At Figure 3 colour differences of prints affected by rub resistance test provided 6 hours after printing (Fig 3a) and 24 hours after printing ((Fig 3b) are presented.

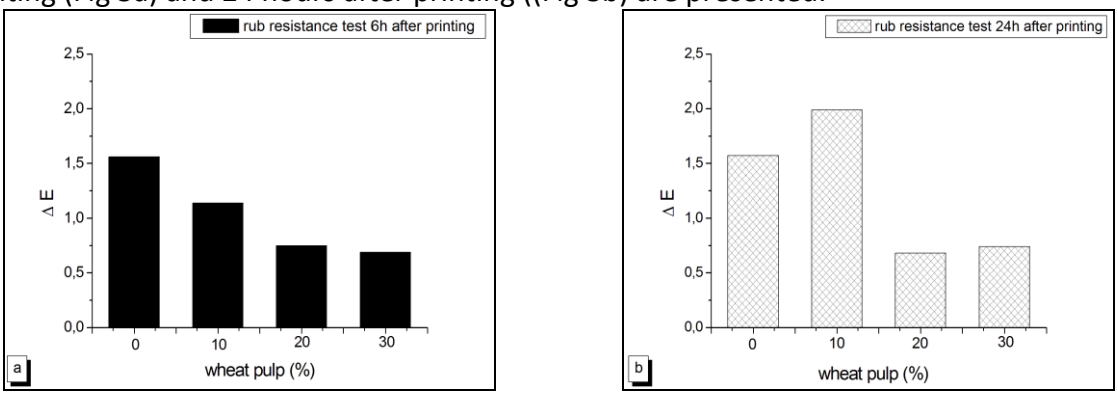

Figure 3: The Euclidean colour difference (ΔE_{00}) of prints affected by rub resistance test: a) 6 hours after printing; b) 24 hours after printing*

Results of this analysis simulate some of the stresses that a printed substrate is subject to during its life cycle (printing process, transport, distribution, storage, handling and end-use) [7]. During the rub resistance analysis ink could be rubbed off in higher or smaller share from the treated printed substrate. The Euclidean colour difference (ΔE_{00}*) refers to the distance between two colours in the CIELab colour space. Therefore, from its value it can be concluded how the colour is different from the original sample (unrubbed printed substrate). According to tolerance definition $\Delta E_{00}^{*} \leq 2$ is classified as very small noticeable difference for standard observer, while $\Delta E_{00}^{*} = 5$ is defined like big noticeable difference in the colour whose standard observer can recognized. From results of measurements presented at Figure 3a, it is clearly notable that with increasing the share of wheat pulps in paper substrate the rub resistance of prints is increasing (ΔE_{00}* is decreasing) when the analysis were done 6 hours after printing. By extension drying time of the ink to 24 hours, the worse rub results were achieved (Figure 3b). It is important to point out that the use of

straw pulp in the production of paper for newsprint provides acceptable print quality considering the rub resistance of prints.

Conclusion

Wheat pulp in newsprint provides good rub resistance of prints, which means that wheat pulp can be used as a raw material for this grade of paper in commercial newsprint sector. Namely, with increasing the share of wheat pulp in paper, the rub resistance of the prints is better.

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