STIFFNESS OF BLEND PULPS FROM WASTE PAPER AND CHEMI-MECHANICAL FIBRES

Martina Říhová, František Potůček
University of Pardubice, Faculty of Chemical Technology, Institute of Chemistry and Technology of Macromolecular Materials, 532 10 Pardubice, Czech Republic
st27081@student.upce.cz, frantisek.potucek@upce.cz

Abstract

The aim of this study was to investigate bending stiffness characteristics for handsheets made of a blend of secondary fibres and chemi-mechanical pulp from rapeseed straw. To manufacture chemi-mechanical pulp, three cold processes, namely neutral sulphite, alkaline sulphite, and caustic soda, were applied under laboratory conditions. The chemi-mechanical pulping comprises four main operations, viz. chipping, grinding, leaching, and beating. The results obtained showed that the addition of chemi-mechanical pulp to secondary fibres led to a decrease in the bending stiffness and bending modulus of elasticity in the region of reversible deformation.

Keywords: *rapeseed straw; chemi-mechanical pulp; bending stiffness*

Introduction

Rapeseed is widely cultivated throughout the world and considered as the third most oilseed crop after soybean and palm. Its seeds are basically used for production of edible oil and further utilized in biodiesel production [1]. After the harvest of grains, the straw is left in the field as residue and let to be composted or burnt otherwise [2]. However, these agricultural wastes can be utilized as fibrous raw material for pulp and paper production. Fibres from rapeseed straw used as secondary fibres bring better mechanical properties than recycled papers [3]. The objective of the present study was to manufacture chemi-mechanical pulp from rapeseed straw by the cold pulping process at a room temperature under laboratory conditions. For blends of secondary fibres with chemi-mechanical pulp, the bending stiffness, and bending modulus of elasticity were measured using the three-point loading method. The results obtained in this work were compared with those determined for moulded fibre specimens made from secondary fibres only.

Experimental

Rapeseed straw (*Brassica napus* L. convar. *napus*, line genotype Labrador) collected from the field in Polabian lowlands near the city of Pardubice was used as a raw material to chemi-mechanical pulping experiments. The stalks and valves of silique were cut manually into small chips having a length of about 20 mm. After drying at 60 °C for 5 hours, the chips of stalks and of silique valves were ground for 20 – 25 s using a laboratory vibrating mill containing a roller and collar in the milling space. Fine mass of accepts retained on +50 mesh size was used for leaching. The samples of fine material to be leached were blends of the stalks and silique valves in a mass ratio of 2:1. Three various cold pulping processes, viz. neutral sulphite, alkaline sulphite and caustic soda, were applied at an active alkali charge of 16 mass % of Na_2O on oven dry straw. For the liquor-to-straw ratio of 15:1, the leaching was performed for 18 hours at a temperature of 21 – 23 °C. For comparison, the leaching of a blend of stalks and silique valves into tap water was carried out as well.

After four-stage batch washing, the wet pulp was beaten to 43 – 46 °SR using a laboratory conical beater. The suspension of beaten chemi-mechanical pulp was mixed with the secondary fibres obtained by slushing of egg trays in water in a mass ratio of 1:3, and 1:1. Egg trays from Huhtamaki Czech Republic, a. s., were manufactured from a blend of waste papers, namely newspapers, magazine paper, waste corrugated board and non-sorted waste papers. The secondary fibres and chemi-mechanical pulp, as well as their blends were used to prepare pulp hand sheets having basis weight of 520 g m^{-2} on a Rapid-Köthen sheet forming machine. To determine the stiffness properties, the stripes, 15 mm in width and 90 mm in length, were cut from the pulp handsheets.

Using a TIRAtest 26005 device, the bending stiffness was determined by the three-point loading method when the distance between supports was kept at 50 mm (Figure 1). A typical dependence between specimen deflection, *y*, and acting force, *F*, for chemi-mechanical pulp made from rapeseed straw using cold caustic soda process is illustrated in Figure 2.

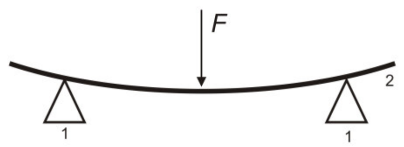

Figure 1. The 3-point loading method.1 supports, 2 specimen of pulp sheet

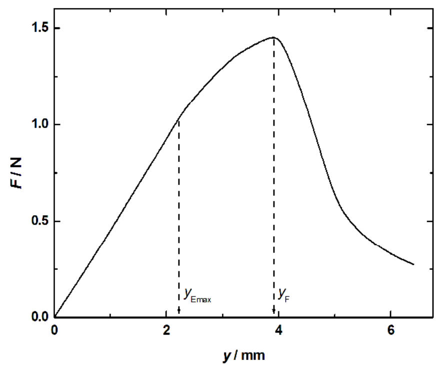

Figure 2. Typical dependence between specimen deflection, *y*, and acting force, *F*, measured for chemi-mechanical pulp hand sheet

Results and discussion

The influence of adding chemi-mechanical pulp to secondary fibres upon bending parameters is shown in the following Figures 3 – 4.

The bending stiffness, *S*, as a property of paper and board, which expresses its rigidity or resistance to bending, is defined as

$$S = \frac{F\,l^3}{48\,y} \qquad (1)$$

where *F*/*y* corresponds to the slope in the region of elastic deformation, at low acting forces, when the dependence of the acting force on the deflection is straight, and *l* is the distance between supports [4].

The results show that the bending stiffness decreases with the addition of chemi-mechanical pulp into secondary fibres (Figure 3). In comparison with secondary fibres, the bending stiffness measured for a blend of secondary fibres and chemi-mechanical pulp (CMP) in a mass ratio of 1:1 was lower by nearly 30 %. For a blend with 25 % of CMP, the bending stiffness of handsheets containing mechanical pulp (MP) and CMP after cold caustic soda process is greater than that of pulp containing CMP after cold neutral sulphite and alkaline sulphite processes.

However, it is known that the bending stiffness increases strongly with increasing the thickness of test specimen, *h*, theoretically with the third power of pulp sheet thickness, *e. g.*, Potůček *et al.* [5] found that $S \approx h^{2.81}$ and $S \approx h^{3.11}$ for moulded fibre products, depending on manufacturing conditions. Hence, the bending stiffness results depend not only on composition of stock used for handsheets, but also on their thickness. While for secondary fibres the thickness of hand sheet was only 0.88 mm, the addition of 25 % and of 50 % of

CMP to the secondary fibres stock brought an increase in handsheet thickness of 0.96 to 1.16 mm, and of 1.00 to 1.43 mm, respectively.

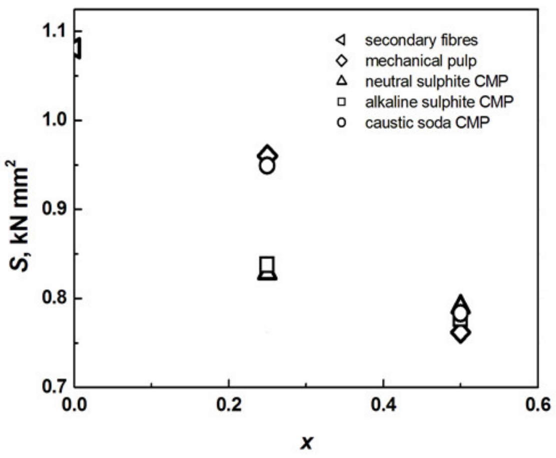

Figure 3. Influence of mass fraction of CMP, *x*, on the bending stiffness, *S*

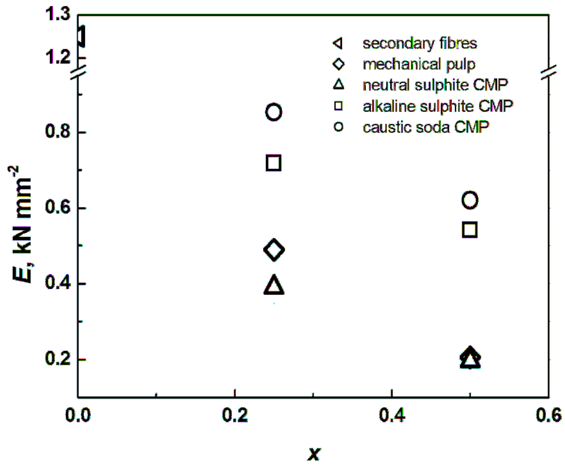

Figure 4. Influence of mass fraction of CMP, *x*, on the bending modulus of elasticity, *E*, in the region of reversible deformation

The bending modulus of elasticity in the region of reversible deformation, *E*, is defined as

$$E = \frac{F\,l^3}{4\,y\,b\,h^3} \qquad (2)$$

where *b* is the specimen width, *h* is the specimen thickness, and the meaning of other symbols is the same as in Equation (1). Thus, Equation (2) may be written as $E = 12\ S\ /\ (b\ h^3)$. Our previous results show that the bending modulus of elasticity is not appreciably different for groundwood specimens with various thicknesses [5].

The influence of the presence of CMP in a blend with secondary fibres on the bending modulus of elasticity is shown in Figure 4. It is evident that the bending modulus of elasticity decreases with increasing the mass fraction of CMP and MP. The greatest values of the bending modulus were measured for a blend of secondary fibres with caustic soda chemi-mechanical pulp. On the contrary, the lowest values of the bending modulus were achieved for neutral sulphite chemi-mechanical pulp in a blend with secondary fibres at both levels of CMP addition.

The pulp handsheets prepared from a blend of secondary fibres with addition of CMP or MP were less elastic in comparison with sheets from secondary fibres only. However, the influence of CMP addition is ambiguous.

Conclusion

The preliminary results obtained in the scope of our study proved that the addition of chemi-mechanical pulp prepared by the three cold processes to secondary fibres led to a decrease in bending stiffness properties. With respect to current knowledge on chemi-mechanical pulping of rapeseed straw, further studies should be developed to confirm the suitability of rapeseed as a future non-wood fibre source.

Acknowledgements

This work was supported by the Internal Grant Agency of University of Pardubice under the research project SGSFChT_2015003.

References

[1.] POTŮČEK, F. and MILICHOVSKÝ, M. *Rapeseed straw as a possible source of non-wood fibre materials*. Cellulose Chemistry and Technology, 2011, vol. 45, no. 1–2, pp. 23–28.

[2.] SAMARIHA, A., KASMANI, J. E., KIAEI, M. and SHURMASTI D. K. *ChemoMechanical pulping (CMP) of rapeseed residues*. World Applied Sciences Journal, 2011, vol. 13, no. 5, pp. 1000–1004.

[3.] GONZÁLES, I., ALACALÁ, M., ARBAT, G., VILASECA, F. and MUTJÈ P. *Suitability of rapeseed chemithermomechanical pulp as raw material in papermaking*. BioResources, 2013, vol. 8, no. 2, pp. 1697–1708.

[4.] POTŮČEK, F., ČEŠEK, B., DOMIN, P. and MILICHOVSKÝ M. *Stiffness of Moulded Fibre Products.* Cellulose Chemistry and Technology, 2007, vol. 41, no. 4–6, pp. 277–281.

[5.] POTŮČEK, F., ČEŠEK, B. and MILICHOVSKÝ, M. *Bending stiffness of groundwood sheets with and without sugar beet pulp addition*. Cellulose Chemistry and Technology, 2008, vol. 42 no. 7–8, pp. 413–419.

Abstrakt

Cílem práce bylo zjistit ohybovou tuhost pro listy vlákniny ze směsi sekundárních vláken a chemicko-mechanické buničiny z řepkové slámy. K výrobě chemicko-mechanické vlákniny byly použity tři studené procesy, a to neutrální sulfitový, alkalický sulfitový a natronový, které byly uskutečněny za laboratorních podmínek. Chemicko-mechanické zpracování zahrnuje čtyři hlavní operace, a to stříhání, mletí ve vibračním mlýnu, vyluhování a mletí v kuželovém mlýnu. Získané výsledky ukázaly, že přidáním chemicko-mechanické buničiny k sekundárním vláknům vede ke snížení tuhosti a modulu pružnosti v ohybu.