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White water recirculation as a means to evaluate fines properties

Introduction

Among the different components and fractions involved in the pulp and paper industries and related processes, fines have been lately drawing attention. The effect of fines during paper formation as well as the impact on sheet properties has been widely analysed. When it comes to the evaluation of their effects on handsheet properties, a defined amount of fines is required to allow extrapolation of the results obtained.

Fines are considered by definition as the fraction of pulp which passes through a 200-mesh screen of a fibre length classifier according to the TAPPI Test Method T 261 Cm-94. This category can be divided into fines from mechanical and fines from chemical pulps. The fines from chemical pulps are further divided into primary and secondary fines. They are similar in size, but their effect on parameters like dewatering, mechanical properties and many more differ. Primary fines are present after the pulping process and consist mainly of parts from the middle lamellae, ray and parenchyma cells and fibre debris and do show a higher extractives and lignin content than the whole pulp. Secondary fines are produced during refining and are usually of a more fibrillar nature. Secondary fines bring fibres into closer contact and enhance fibre-fibre bonding [1, 2], and therefore lead to a stronger increase in tensile strength compared to primary fines [3]. These previous studies show that fines have an important influence on various properties of paper, such as its thickness, tensile strength, dewatering, air permeability, and light scattering. To study the effects of different types of fines at the laboratory scale, the primary challenge is to retain a constant amount of fines in the handsheets formed. In this study, a procedure that easily allows a constant fines content in the handsheets as well as the determination of the fines content was developed. With this method, the effects of primary fines, secondary fines and a cellulosic filler on handsheet properties were investigated as exemplary results.

Materials and Methods

The procedure studied here is based on a white water recirculation system. In this set up, the handsheets are formed like in a standard Rapid-Köthen sheet former equipment, but the water used to form the handsheet is recirculated within the system and used for the next handsheet, i.e., the fines not retained during sheet formation circulate within the white water system, allowing steady-state fines content to be reached after some handsheets are formed. At this point, every subsequent sheet produced contains the amount of fines originally present in the feed suspension.

Using this method, handsheets containing a constant and determined amount of fines (4,8 %) were formed and conditioned for 24 h. After conditioning, the thickness (DIN EN ISO 534:2011), air permeability (ISO 5636-3:2013), and breaking length (DIN EN ISO 1924-2:2009) were determined. The handsheets formed had a grammage of 60 g/m². The mesh chosen was a key parameter as it determined the amount of fines retained. Three different mesh sizes were used; 120-mesh (125-µm openings; standard mesh for sheet forming), 325-mesh (44-µm openings), and 500-mesh (25-µm openings) screens were used.

All tests were performed using a flash-dried, bleached softwood Kraft pulp (a mixture of spruce and pine). Using this pulp, several samples were prepared for investigation. Primary fines were separated from the pulp according to SCAN-CM 66:05 using the Britt dynamic drainage jar. The fines-free pulp was refined in a valley beater for 2 hours to produce secondary fines, which were separated from the pulp afterwards. A third kind of fines material used in these trials was a commercially available cellulosic filler material. The amount of fines added to the feed suspension was 4.8%, which corresponds to the amount of primary fines originally present in the pulp sample used.

The amount of fines retained in each handsheet formed was determined using an L&W Fiber Tester Plus (based on morphological characterization). The L&W Fiber Tester Plus allowed for the measurement of key fiber morphological parameters such as the fines content. The fines content was defined as the arithmetic proportion of particles with lengths below 200 µm.

Results

After handsheet formation with three different meshes and subsequent L&W Fiber Tester Plus analysis, the fines content *versus* the number of sheets formed using white water recirculation was determined and is represented by the arithmetic proportion of particles having lengths below 200 µm (Fig.1). As expected, the smaller the pore size screen, the higher the amount of fines retained. Therefore, the 500-mesh retained more fines than the others. As more handsheets were formed, the fines content increased until levelling out, achieving the so-called “steady-state”. From Fig. 1, it is apparent that steady-state was achieved after three handsheets for the 500-mesh screen, five for the 325-mesh screen, and seven for the 120-mesh screen. Therefore, using a 500-mesh screen would allow for the least number of handsheets to be discarded. In practice, the small openings of this wire make its application very difficult, as the high capillary forces between the sheet and mesh do not allow the sheet to be removed without damaging its surface to some extent, leaving the sheets useless for further evaluation. For this reason, the 325-mesh screen was chosen for use in subsequent trials to determine the influence of primary fines, secondary fines, and a mechanically produced cellulosic filler material on the handsheet properties, based on the fines-free unrefined softwood Kraft pulp.

The steady-state is achieved faster with the 325-mesh, compared to the 120-mesh.

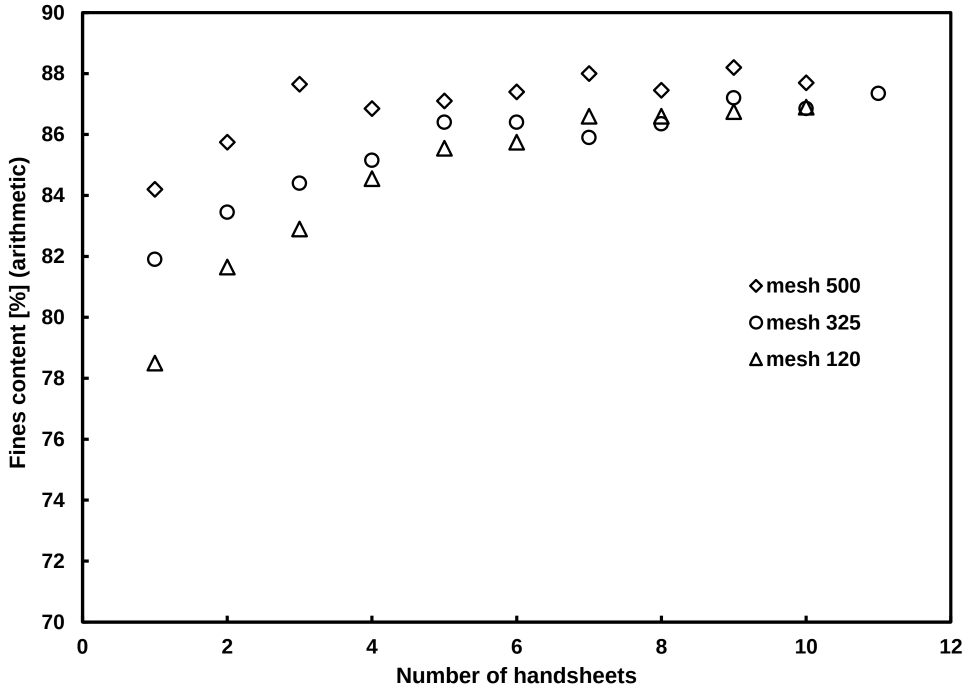

Figure 1. Comparison between the fines retention and the mesh size

The results obtained using the 325-mesh wire are presented in Fig. 2. To ensure that the fines content was constant in the sheets evaluated, seven handsheets were discarded before testing. The effects of the primary and secondary fines, as determined in this study, were in accordance with data found in literature. The addition of secondary fines resulted in higher sheet density with higher tensile strength and correspondingly lower porosity and slower dewatering. This effect was explained by Bäckström *et al.* [4], who claimed that the creation of higher capillary forces between the fines and the fiber surface improved the paper properties. Secondary fines are more fibrillar and have a higher charge content than primary fines, thus making them more effective in terms of sheet densification [3]. According to Chen *et al.* this increases both the bonded area and the bond strength because they act as binders between long fibers [5]. The increase in tensile strength observed by Bäckström *et al.* [4] was up to 30% when 10% secondary fines were added and 15% when primary fines were added. In the present work, the breaking length was 84% higher when secondary fines were added than when primary fines were added.

Comparison of the effects of primary fines and the cellulosic filler material revealed similar properties with slightly better dewatering achieved using the cellulosic filler. The mechanically produced cellulosic filler material was composed almost exclusively of fine particles but did have considerably higher width, according to the L&W morphology measurements. These more spherical particles may lead to higher porosity, which was not determinable for these samples because 5,000 mL/min is the upper limit of the measurement (see Fig. 2). The pores were not plugged by this material as was the case with the primary and, even more so, secondary fines. This also explains the improved dewatering.

From these results, one can conclude that the cellulosic filler material acted as a spacer within the sheet.

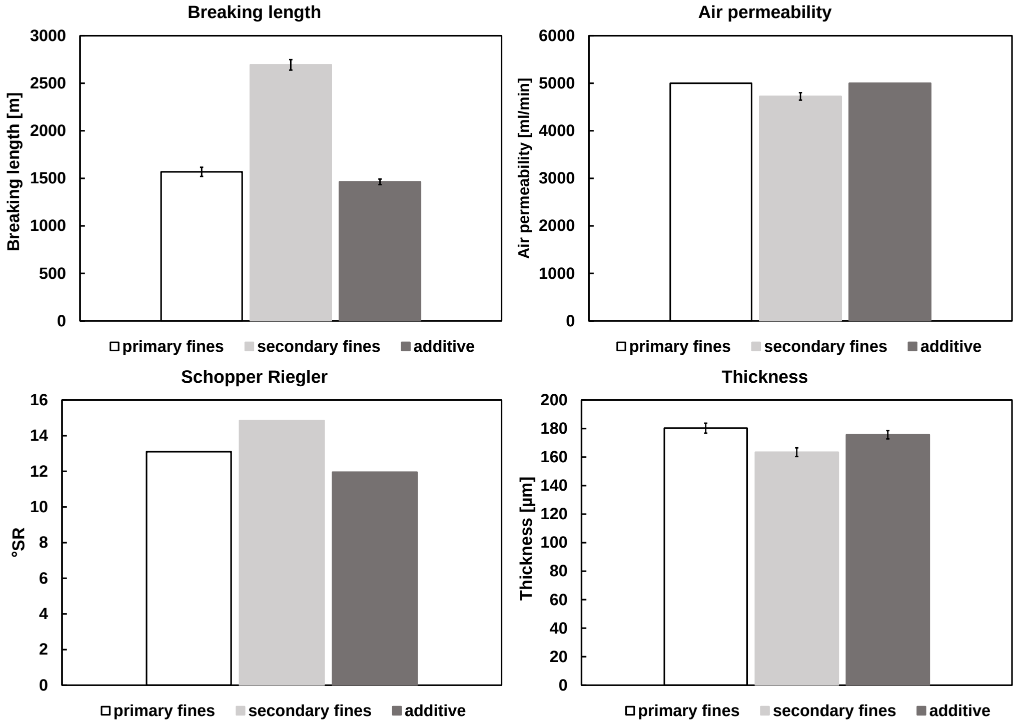

Figure 2. Effect of primary fines, secondary fines, and mechanically produced cellulosic filler material on handsheet properties.

Conclusions

The established method provides a constant amount of fine material in the handsheets and allows for easy determination of the fines content using an L&W Fiber Tester Plus. This procedure enables the evaluation of the effects of fines and other types of additives on various pulps and their properties. Fewer handsheets must be discarded when the mechanical retention of the wire used is as high as possible. In practice, the 325-mesh wire was the finest wire applicable. Regarding fines properties, secondary fines had the strongest effect on the breaking length. Primary fines and the cellulosic additive had similar influences on handsheet properties.

References

[1] J. Sirviö, I. Nurminen, and K. Niskanen. A method for assessing the consolidating effect of fines on the structure of paper. Pages 187–192, 2003.

[2] J. Sirviö, and K. Niskanen. *Fibres and bonds*. Fapet Oy, Jyväskylä, 2nd edition. 2008.

[3] Y. Xu and R. Pelton. A new look at how fines influence the strength of filled papers. *Journal of Pulp and Paper Science*, 31(3):147–152, 2005.

[4] M. Bäckström, M.-C. Kolar, and M. Htun. Characterisation of fines from unbleached Kraft pulps and their impact on sheet properties. *Holzforschung*, 62(5):546–552, 2008.

[5] J. Chen, M. Zhang, Z. Yuan, and J. Wang. Improved high-yield pulp network and paper sheet properties by the addition of fines. *BioResources*, 8(4):6309–6322, 2013.