Application of a coating of co-processed microfibrillated cellulose and mineral at the wet end

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Microfibrillated cellulose (mfc) and nanocellulose (nfc) are currently creating great interest both in paper and paperboard and in many applications beyond. For use in paper, low cost production methods are needed in order to make the use of these materials economically viable. FiberLean® Technologies have developed such a method, which involves the co-grinding of pulp fibres with fine mineral particles to generate mfc. The main application of this technology has been as an additive to the papermachine wet end in fine paper grades to increase wet web, tensile and surface strength, reduce porosity and allow the use of much-increased filler levels.

Over 30 full scale machine trials of FiberLean® mfc have now been run, all of which have added the material to the wet end, in most cases with the aim of increasing filler level. A typical application might aim to use 2% mfc addition to achieve an increase in filler content from 20% to 30%. Figure 1 shows the mfc dose used and filler increase achieved in trials carried out up to 2014. Three on-site, full scale plants have been constructed so far at papermills in North America and Asia for this purpose.

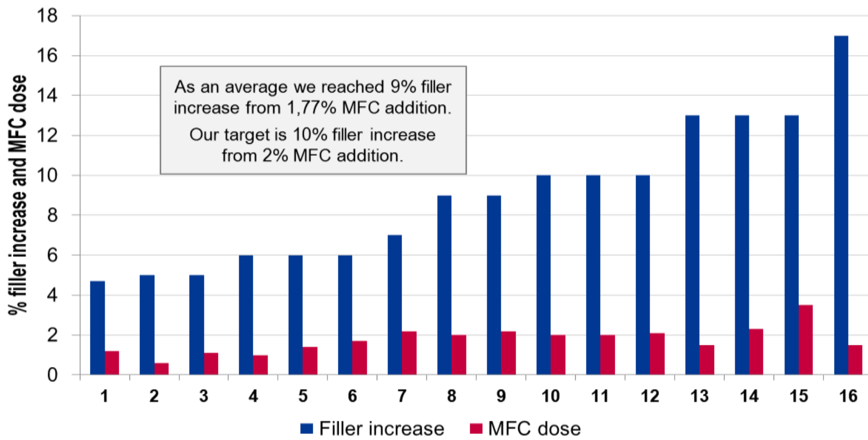

Figure 1. MFC dose and filler increase achieved in graphic paper (UWF/CWF) trials up to 2014

Full scale trials of the product have also been carried out in packaging grades, where the maintenance or improvement of mechanical properties is of critical importance. For example, Figure 2 shows how mfc has been used to allow the addition of filler to the top and bottom layers of a folding boxboard, thus enabling the mill to reduce the weight of the layers, increase the proportion of bulky mechanical fibre used and improve brightness and smoothness, whilst maintaining critical properties such as bulk and stiffness and reducing overall cost.

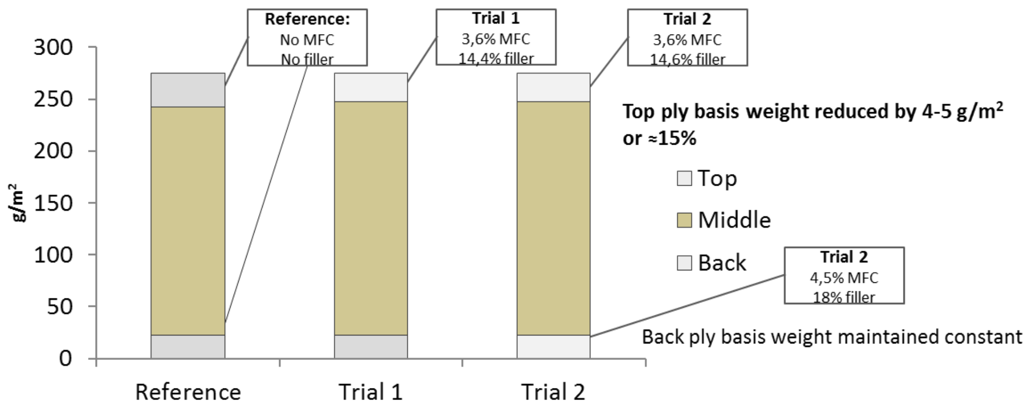

Figure 2. Mill trial results using co-ground mineral and mfc to increase filler loading in the outer layers of folding box board

Both mfc and nfc have been considered as alternative binders for coatings by a number of groups. However, the highly viscous nature of suspensions of these materials restricts them to very low solids content (<5%) in order to achieve a flowable formulation for coating. Coating by conventional means is thus not possible, although it has been recently demonstrated[1] that good coverage can be achieved using a high shear slot coater; because the suspensions are extremely shear-thinning acceptable flow properties can be achieved with this configuration, but the amount of water to be evaporated remains very high and thus limits the practical coatweight that can be achieved.

Alternatively, application of a coating of mfc and mineral pigments at the wet end eliminates the need for high solids content, as water can be removed by conventional drainage, pressing and drying on the machine. The challenge to overcome is the roughness of the base at that point; the coating needs exceptionally good holdout to avoid penetrating into the open spaces between fibres before consolidation in the presses and dryers.

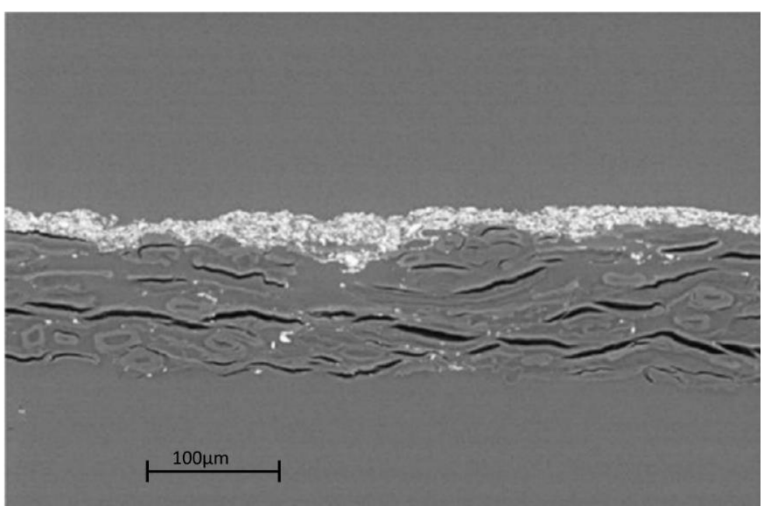

Figure 3. SEM Cross section of unbleached long fibre Kraft linerboard with 28gsm coating of 80% $CaCO_3$/20% mfc applied at the wet end

We have demonstrated at laboratory and pilot scale that a slurry of co-ground mineral and mfc can be applied on top of a forming web with a curtain coater at mineral content of up to 80%. The coating can be dewatered on the web, shows very little penetration into the base and excellent coverage.

Figure 3 shows an SEM cross-section of sample made on a pilot papermachine, where 28 gsm of an 80%/20% mix of ground $CaCO_3$/mfc has been applied via a curtain coater onto an 82gsm unbleached kraft softwood base at the wet end. This coating contains only 5.6gsm of mfc. The formation of the base was fairly poor, and the surface was extremely rough at point of contact of the curtain with the web, but nevertheless excellent coverage and minimal penetration has been obtained. An ISO brightness of 74% was obtained despite the very low brightness (15% ISO) of the base, because of the high $CaCO_3$ content of the layer. Increasing the coatweight to 40gsm allowed a brightness of above 80% ISO to be obtained. Data obtained at the pilot scale, and also in the lab using an adapted handsheet method to coat wet sheets before pressing, agrees well with the Kubelka-Munk model for two distinct layers and suggests that a brightness of 60% ISO can be achieved with around 10gsm of coating containing 2gsm of mfc (Figure 4).

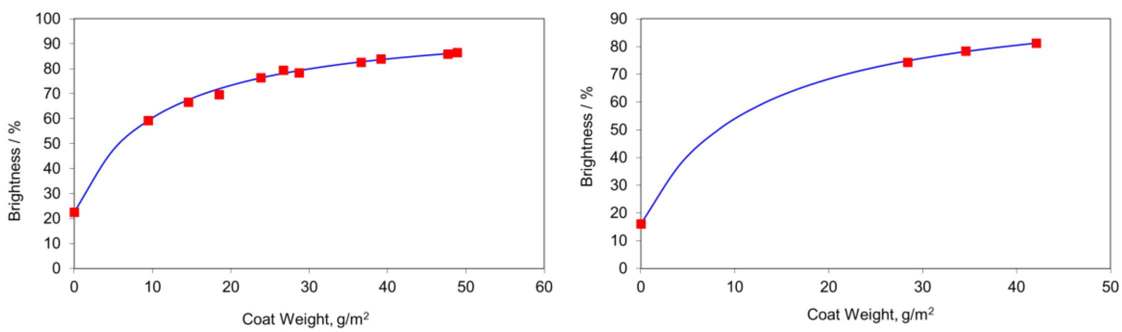

Figure 4. Brightness vs coatweight for 80% $CaCO_3$/20% mfc on unbleached Kraft base, fitted to Kubelka-Munk model. Handsheet data (left), Pilot machine data (right)

The mechanical properties of the pilot scale wet-end coated sheet were very promising. In particular, the Scott Bond was the same as the base sheet – delamination occurred in the brown layer and not at the interface or in the coating. The overall burst index was reduced; not surprisingly the coating of 80% $CaCO_3$ is weaker than the 100% long fibre base. However, a comparison with similar pilot scale work we have done with white top liner shows that the burst index of this layer is equivalent to that of a conventional, all bleached hardwood white top layer at 15% loading of scalenohedral precipitated calcium carbonate, where a 60gsm top layer was required to achieve 80% ISO brightness on a 25% ISO brightness base. Hence the lower weight of the white layer made by the new method would allow more unbleached fibre to be used to make a stronger product at the same overall grammage.

The most remarkable effect of the wet end mfc coating is on sheet surface properties. The basepaper used is very porous – the uncoated base had a Bendtsen porosity value of nearly 2000 ml/min. With the 28 gsm 80/20 $CaCO_3$/mfc coating layer this is reduced to 66 ml/min, and with a 42gsm coating it drops further to 30 ml/min. Likewise with 28gsm of coating the Bendtsen smoothness was reduced from 1580 ml/min to 520 ml/min.

This work demonstrates that the co-ground mineral/mfc product can potentially be used as a white top layer for linerboard by applying it to the wet end with a curtain coater. This could be achieved on a Fourdrinier machine with relatively minor modifications, and crucially without the need for a multilayer former.

[1] Kumar, V., Elfving, A., Koivula, H., Bousfield, D. and Toivakka, M., 2016. Roll-to-roll processed cellulose nanofiber coatings. Industrial & Engineering Chemistry Research, 55(12), pp.3603-3613