

FiberLean MFC grinders for the integrated production of MFC in the paper and board industry

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INTRODUCTION:

Use of MFC in paper and board allows generally improved sheet mechanical properties and lower porosity and hence better coating hold-out. Applications include graphic papers, white outer packaging layers, specialty papers, tissue, and various food service applications (1). Typically, cost savings of greater than €20/ tonne of paper are achieved in relevant situations.

However, whilst the use of MFC in the paper and board industry has been explored for many years, the uptake has been slow despite the undoubted technical benefits. Obstacles to uptake have included:

- Issues with complexity and reliability of MFC production equipment.
- Lack of regulatory clearance, in particular, food contact clearance for MFC.
- Lack of availability of MFC for running adequate production trials before committing to on-site production.
- The relatively high cost of MFC.

These obstacles have now been removed:

- FiberLean MFC grinders use simple, reliable stirred media mill technology to produce low cost, high performance MFC from a wide range of virgin and recycled chemical pulps.
- The resultant MFC has a coarse macrostructure along with a high level of surface micro and nano fibrillation. This allows improved performance and cost savings compared to MFC produced using other techniques.
- After an extensive regulatory programme, MFC from FiberLean MFC grinders now has broad food contact clearance.
- Multi-tonne quantities of MFC are available from a central production facility for running trials and interim supply.
- On-site MFC production using FiberLean MFC grinders can be integrated into the wet-end of paper production for cost effective production.

Production of MFC using FiberLean MFC grinders

Introduction

FiberLean MFC grinders are stirred media mills (Figure 1), they show benefits compared to alternative technologies for MFC production. They are easy to operate in a continuous, single pass production mode, with high throughputs compared to the footprint and low capital cost. Furthermore, stirred media mills are reliable and have high plant availability, as they do not rely on precision-engineered components for fibrillation which can be expensive to replace, nor do they use narrow orifices that are easy to block. No chemical additives are used.

The grinding vessel comprises a chamber equipped with an impeller and partially filled with grinding media beads. Fibrillation occurs when cellulose fibers are trapped between colliding media particles. The MFC product leaves the grinder through door screens, located in the walls of the chamber, that retain the grinding media. The high media surface area facilitates efficient fibrillation, and the wide range of operating variables and conditions allows tuneable production. This allows the production of high quality MFC from a wide range of feed pulps.

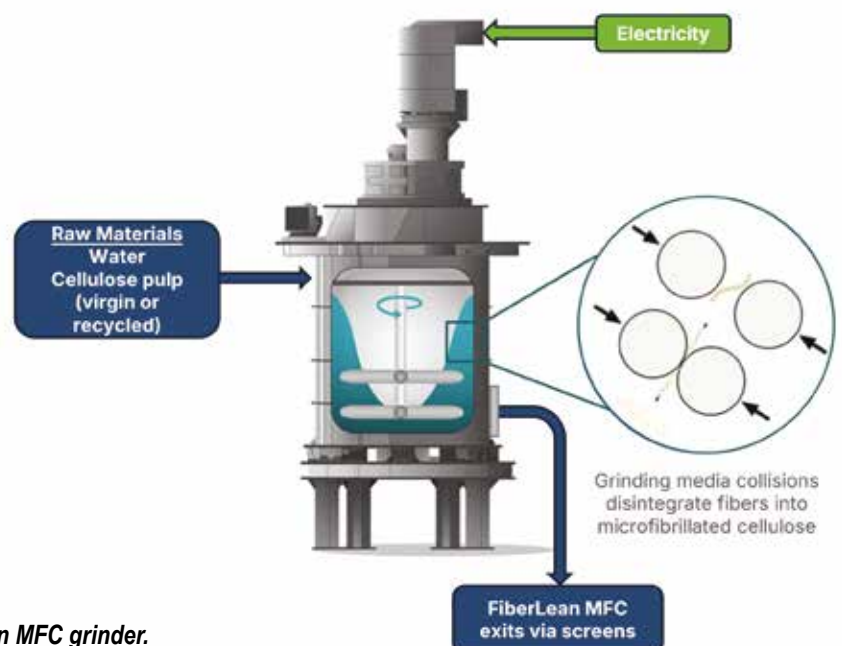


Figure 1: Schematic of FiberLean MFC grinder.

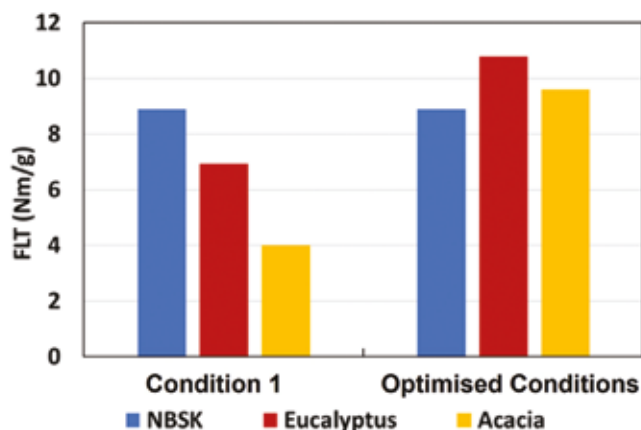


Figure 2: Quality (FLT) for MFC prepared from NBSK, eucalyptus and acacia pulps.

Figure 2 (Above) shows MFC quality (FLT) for MFC prepared from NBSK, eucalyptus and acacia pulps. The left-hand data cluster show data for MFC samples prepared under conditions optimised for NBSK and these data show that MFC prepared from eucalyptus and acacia under these conditions had sub-optimal performance. The right-hand data cluster show data for MFC samples prepared where the conditions were varied to allow preparation of optimised quality MFC from all the pulps.

Comparative performance

Typically, for paper and board applications the FiberLean MFC grinder production conditions are selected to give an MFC product having a coarse macrostructure but with a highly fibrillated surface microstructure (Figure 3 *Top right*). This allows an optimised balance of bonding properties in the resultant paper sheets whilst maintaining retention during production (2).

Figures 4 - 7 (*Below*) show data from laboratory studies that investigated the effect of MFC in paper. Three sets of MFC samples were used. Two sets were produced using a FiberLean MFC grinder and the third set was produced using competitive refiner-based technology. The same eucalyptus pulp sample was used for MFC production in each case.

Figure 4: Variation of MFC fiber length with MFC production energy input for MFC produced using FiberLean MFC grinders and competitive refiner-based technologies.

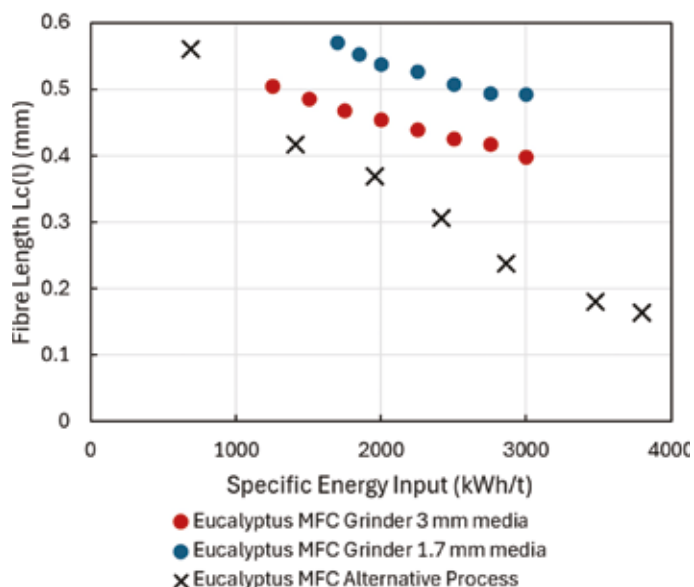
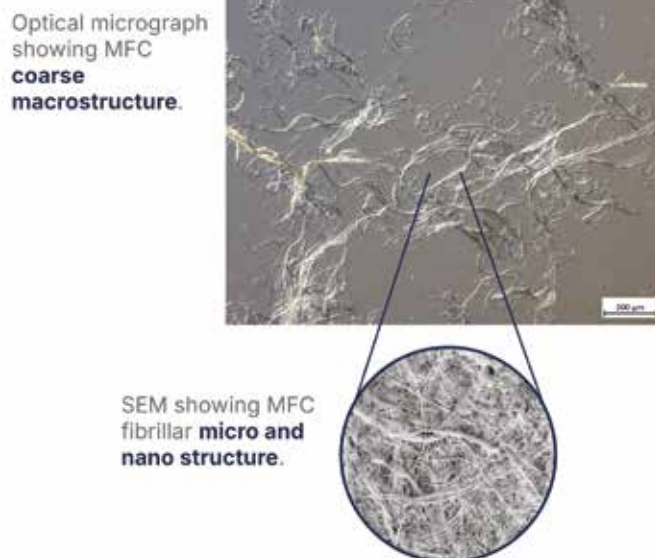


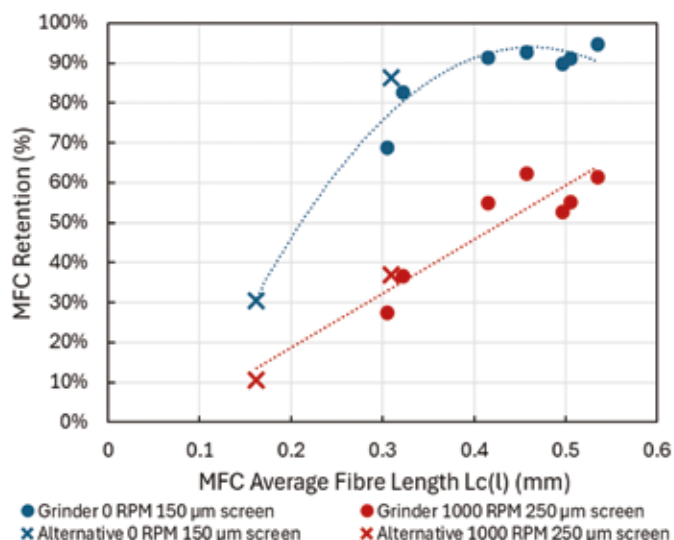
Figure 3: Optical and scanning micrographs showing the coarse macrostructure and fine micro and nano structure of FiberLean MFC grinder produced MFC.

Figure 4 shows how MFC fiber length (measured with an optical fiber analyser and representative of the MFC macrostructure) varies with grinder energy input. The data show that FiberLean MFC grinder produced MFC samples had coarser macrostructure than the refiner produced samples.

Figures 5 and 6 show data for paper sheets containing the MFCs produced under different conditions

Figure 5 shows how the Scott Bond of the paper sheets varies with MFC type and production energy. The data show that as expected the Scott Bond increases with MFC production energy input in all cases and that there is no difference in Scott Bond performance between the FiberLean grinder produced MFC samples and the refiner-based MFC. Scott Bond and other surface strength properties of paper are dependent on MFC surface microstructure and, the microstructure developed using FiberLean MFC grinders and refiners are similar.

Figure 7: Variation in MFC retention with MFC fiber length for MFC produced using FiberLean MFC grinders and competitive refiner-based technologies.



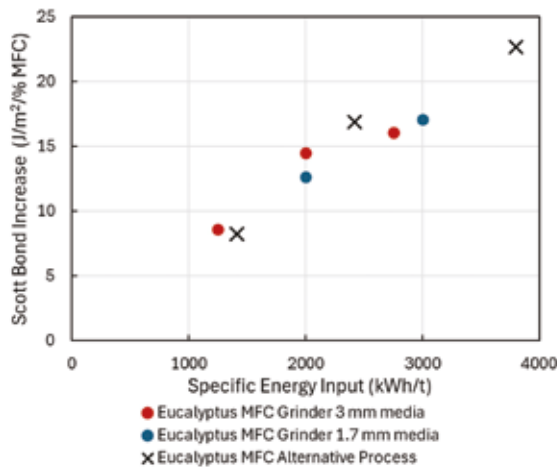


Figure 5: (Above) Variation of paper sheet Scott Bond with MFC production energy input for MFC produced using FiberLean MFC grinders and competitive refiner-based technologies.

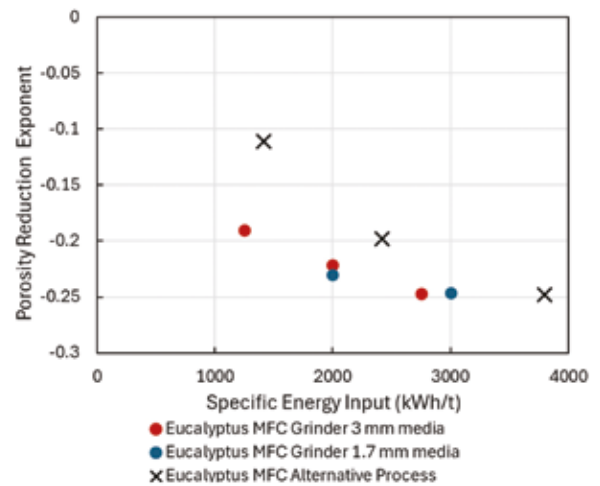


Figure 6: (Above) Variation of paper sheet porosity with MFC production energy input for MFC produced using FiberLean MFC grinders and competitive refiner-based technologies.

Figure 6 shows how sheet porosity varies with MFC type and production energy. The data show that the porosity reduction obtained using MFC was much higher when FiberLean grinder produced MFC was used. Sheet porosity is dependent on both the microstructure and macrostructure of the MFC used and the coarser macrostructure obtained with FiberLean grinder produced MFC results in greater reductions in sheet porosity.

Figure 7 shows that MFC retention is dependent on MFC size or macrostructure. FiberLean grinder produced MFC has a coarser macrostructure than refiner produced MFC and hence has higher retention.

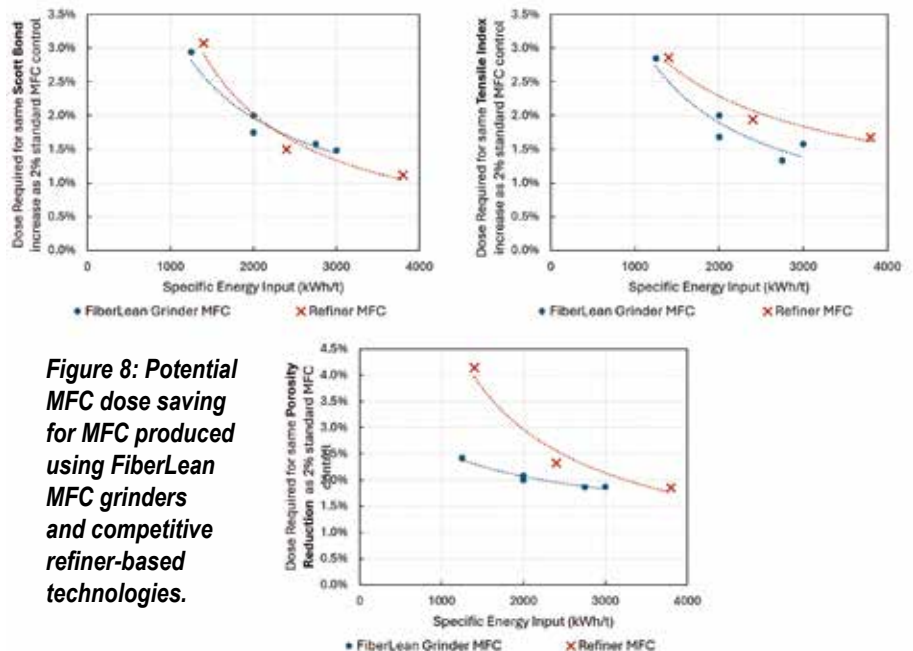
Figure 8 shows data from a separate but similar laboratory study. In this case, use of FiberLean grinder produced MFC allowed potential dose savings compared to refiner MFC of about 30% for equivalent sheet porosity, and about 15% for equivalent sheet tensile strength. There were no savings for equivalent sheet Scott Bond. These data were from laboratory hand sheet studies having very high retention. In full-scale, on-machine situations the higher retention associated with FiberLean MFC grinder produced MFC gives further dose savings compared to refiner produced MFC.

Figure 9: Three sizes of FiberLean MFC grinders.

	FiberLean G125	FiberLean G175	FiberLean G250
Typical use case	Moulded fiber producers	Tissue mills, small paper mills	Medium to large paper and board mills
Footprint (m)	1.1 × 1.1	2 × 2	2.6 × 2.6
Max. height (m)	3.8	4.9	7.5
Capacity	kg/h tpa	47 400	140 1200



Figure 8: Potential MFC dose saving for MFC produced using FiberLean MFC grinders and competitive refiner-based technologies.



Operation

Three sizes of FiberLean MFC grinders are available having nominal capacities of 1200, 400 and 100 dry metric tonnes of MFC per year (Figure 9). These sizes are targeted for the graphic and packaging, tissue and specialty, and moulded object markets, respectively. The designs are modular and multiple units can be installed. Typical variable production costs comprise energy of

~1500-2500 kilowatt hours per dry metric tonne of MFC produced and consumables. Consumables comprise grinding media and grinder door screens. Consumable costs are typically less than €100 per dry metric tonne of MFC. Pulp conversion is greater than 99.5%.

Grinder availability, assuming scheduled maintenance is conducted during planned mill shutdowns is greater than 99%.



Figure 10: FiberLean Technologies Limited MFC production facility in Cornwall, UK.

Regulatory clearance of MFC in food contact applications

After more than a decade of work, food contact clearances are now in place for MFC produced using FiberLean MFC grinders.

Some of these clearances include MFC size parameter limitations and exclude the use of enzymes during MFC production. To date, all the MFCs produced using FiberLean MFC grinders, and FiberLean Technologies Limited production guidance, fall within these allowances.

There are clearances in place with BfR, FDA and in Canada and China (1).

Furthermore, extensive work has shown that there are no negative health effects of using MFC (1) and that MFC is not a nanomaterial (3).

Availability of MFC press cake for trials

The MFC production process operates at low solids (typically less than 3%) and MFC cannot be easily dried and re-suspended at solids contents of greater than about 20%. Twenty percent solids press cake can be used to run trials for concept validation prior to installation of an on-site production facility. (However, the high transportation costs associated with this material precludes most high volume, paper industry applications.)

FiberLean Technologies Limited operates a production facility in Cornwall, UK that can produce up to 2000 dry metric tonnes per year of MFC cake (Figure 10). Typically, MFC cake at ~20% solids is produced from relevant pulp and shipped to the paper mill site for production trials (Figure 11).



Integration of MFC production into the paper making process allows significant cost reduction

FiberLean MFC grinders are easy to operate in continuous, single pass production mode and are, hence, suitable to be integrated into the wet-end of the paper making process. This has been shown to be the lowest cost method for provision of MFC into papermill operations. Integration into existing mill operations allows reduction in peripheral equipment and control systems and therefore reduced capital expenditure and shortened pay back times.

Conclusions

In conclusion, many of the obstacles to the uptake of MFC in paper and board applications have been removed.

MFC can be produced using FiberLean MFC grinders. These stirred media mills are easy to operate in a continuous, single pass production mode, with high throughputs and low capital cost. The mills are reliable and have high plant availability, as they do not rely on precision-engineered components for fibrillation and do not use narrow orifices that are easy to block. No chemical additives are necessary.

FiberLean MFC grinders allow production of coarse and highly fibrillated MFC from a wide range of chemical pulp feedstocks. These MFCs offer improved performance compared to refiner produced MFCs and retain better during the paper making process.

The mills are available in several sizes to suit the applications and the designs are modular. Food contact clearances are in place for FiberLean MFC grinder produced MFC in most markets.

MFC press cake at ~20% solids is available for trials.

Integration of FiberLean MFC grinders into the wet-end of the paper mill production process minimises capital expenditure for provision of MFC into mill operations.

Figure 11: MFC at ~20% solids content.

Acknowledgements

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