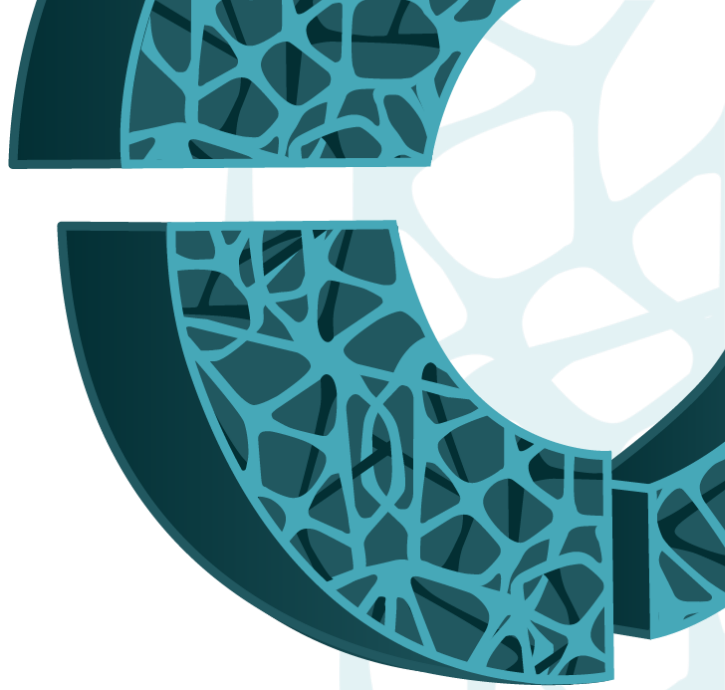
FiberLean® Technologies

Innovative by Nature.



New coating process with MFC proven in full-scale.

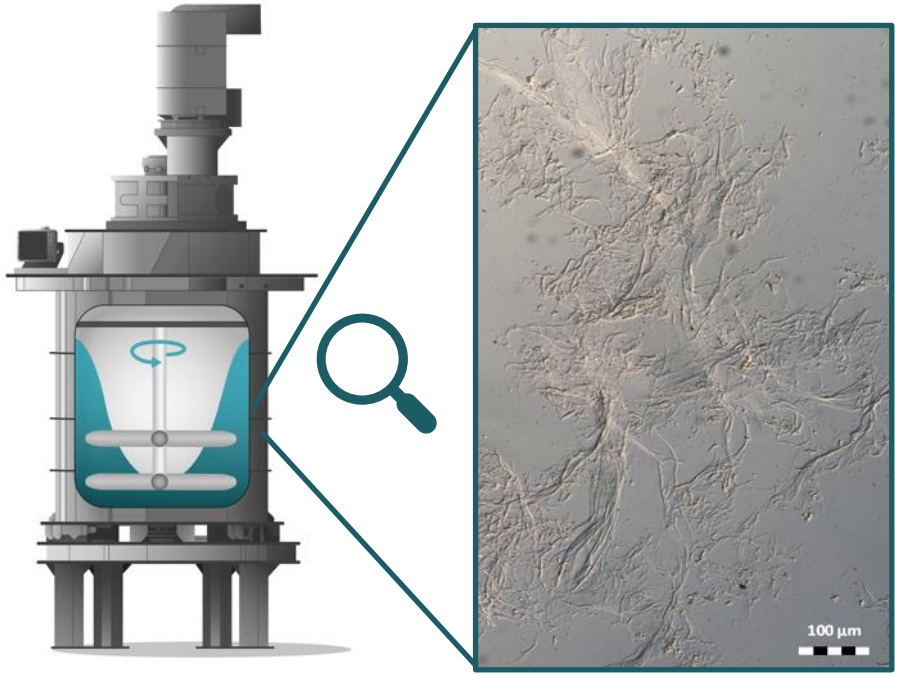
IMPS 2023, München
April 25-27th 2023

Per Svending – Project Leader FiberLean on Top
Tom Larson – Head of Business Development

March 2023

FiberLean Grinding Technology:
The most efficient and effective way of making MFC at scale

Ultra-fine grinding in FiberLean mills



The unique FiberLean® process:

Creates interconnecting fibre

Networks

that are highly-fibrillated for

Strength

and

Performance

Our **robust grinding** process transforms fibres through **milling** with carefully **controlled intensity**, liberating an **optimal "micro fibrillated" network** structure.

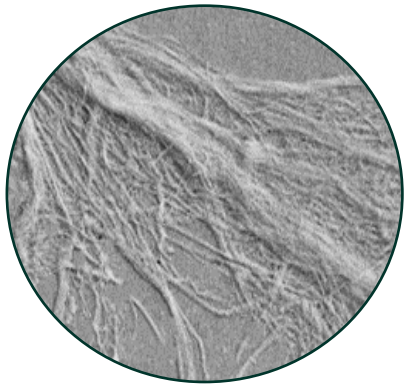
High-performance MFC produced onsite

- ✓ High-throughput continuous operation.
- ✓ Low maintenance costs and high uptime (>95% plant availability).
- ✓ 100% mechanical process, Chemical-free process.
- ✓ Highly-automated modular plant design with online monitoring.
- ✓ Top performance reached in one single stage
- ✓ Low energy consumption and low operating costs

Our MFC Products

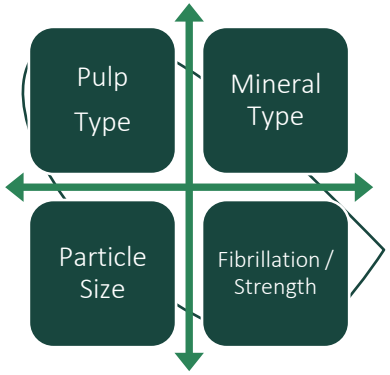
Prepared as low solids slurry

- Highly viscous MFC suspension in water.
- ~1% to 2% solids content (based on fibre).



Unique properties

- Web-like network structure.
- High aspect ratio.
- Very high surface area.
- Recyclable, biodegradable & compostable.
- Food contact safe.



Product variety

- Varied levels of fibrillation and particle size distribution.
- Virtually all pulp types can be used, including recycled feedstocks.
- MFC composites with minerals can also be prepared.

3 product families

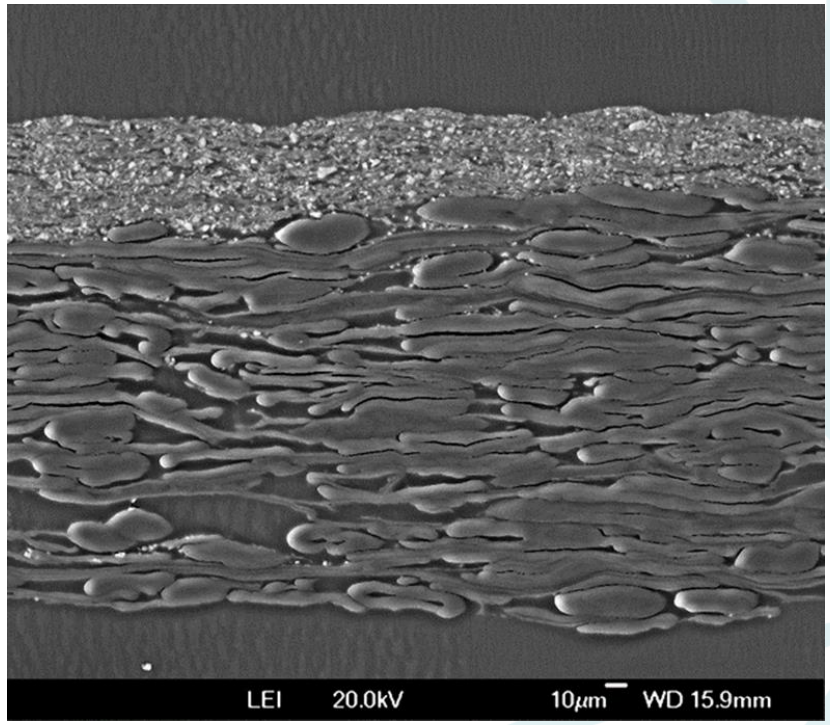
- **MFC** from virgin wood pulps
- **MFC-mineral composites**
- **MFC from recycled**

FiberLean MFC FLy®
MFC from 100% virgin new fibers

FiberLean MFC FLex®
MFC blends with mineral

FiberLean MFC reFLex®
MFC from recycled fibres

FiberLean Technologies surface application of MFC, developed to produce a novel White Top Liner



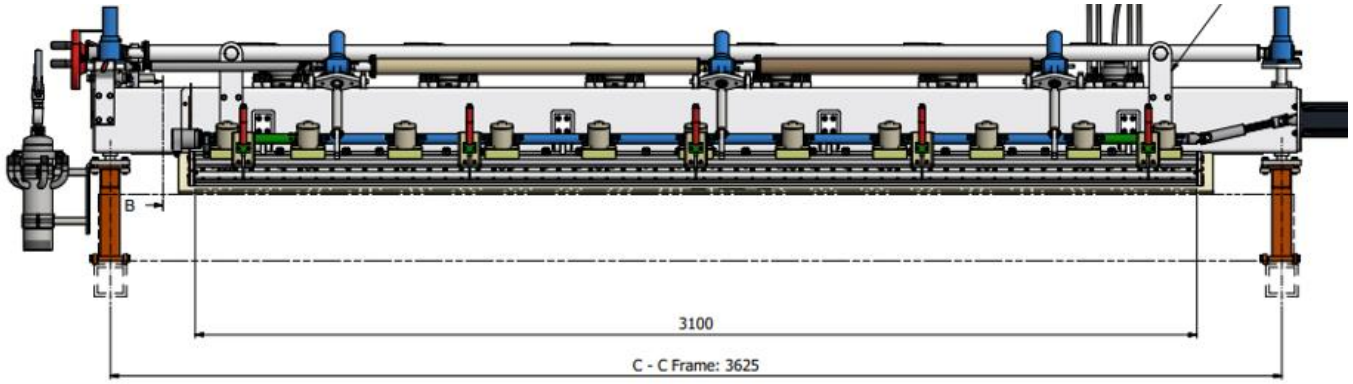
- ✓ Low-cost layer comprising mostly minerals, with MFC as the only binder.
- ✓ Absolute minimal white pulp consumption to produce WTL.
- ✓ Excellent printing properties.
- ✓ High surface strength and delamination resistance.

- ✓ Mineral particles provide a bright, white, printable surface to uniformly cover the dark base.
- ✓ MFC binds mineral particles at the surface, ensuring no penetration into the base and high surface strength.

As presented at IMPS 2022:
Complete equipment available for full-scale trials, starting June 2022

- ✓ Two portable skids with feed system for adding up to 5 ton/hour of White Top layer.
- ✓ Bespoke design ”applicator” for wet-end coating application.

The patented in-house design of the FiberLean applicator



1/10000 sec exposure photographs

Water, 500 m/min

20/80 MFC/$CaCO_3$ 500 m/min

- Specifically designed for application of optimized* MFC with jet speed similar to wire speed, i.e., at high-shear conditions. Gradual shear-thinning of MFC through the approach flow system and applicator with maintained laminar flow.
- Low cost and light weight, for easy mounting across paper machine.
- FiberLean has partnered with a major coating equipment manufacturer to provide the engineering, fabrication and servicing of these applicators.
- FiberLean is committed to continued development of this technology and has multiple additional patents pending. We believe that the FiberLean products and applicator will remain at the forefront of this technology.

*MFC product optimization discussed further later.

The scaled-up equipment and new coating method has been proven to work in full-scale

Feeding the application requires a large flow of MFC-mineral composite. The coating is typically 20-30% of the total WTL weight, i.e. several dry ton per hour. Slurry flows are in the m^3/min range.

Multiple trials now run in different mills with over 100 ton of WTL made.

Having the capability to run such large volume trials is key to industrial evaluation of MFC

MFC trial make-down unit, re-dispersing granulate FiberLean MFC to slurry for use on paper machine.

Merchant Supply of MFC within Europe from Cornwall (UK)
Delivered in IBC Bags as granulate & redispersed into slurry onsite

- ✓ ≤ ~2,000 dmt/year MFC capacity from the UK plant.
- ✓ Operational since Q4 2013.
- ✓ Granulate product form.
- ✓ ~1,000 kg/IBC bag (wet).
- ✓ ~15-18% MFC solids.
- ✓ ~150-180 kg/IBC bag (dry MFC

FiberLean® MFC products optimized for surface application
Carefully selected properties based on years of process & application development

- ✓ Barrier performance
- ✓ Strength / Durability
- ✓ Binding capability
- ✓ Viscosity
- ✓ Drainage

Fibrillation

Particle Size Distribution

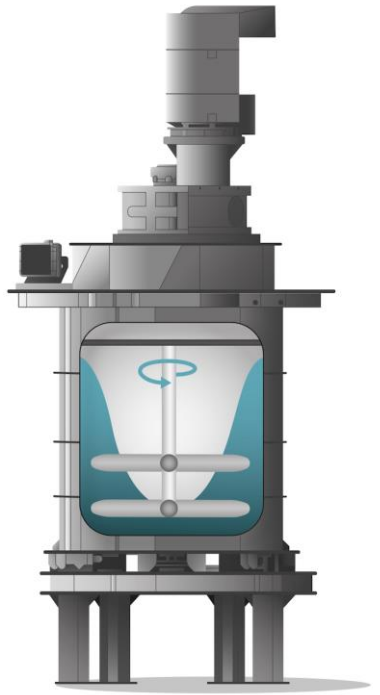
- ✓ Avoidance of applicator blockages
- ✓ Coating uniformity / formation
- ✓ Viscosity
- ✓ Drainage

- ✓ Process throughput to match peak demand
- ✓ Dose / Coat weight required
- ✓ Cost effectiveness

Cost vs. Performance Relationship

Large Aspect Ratio Networks

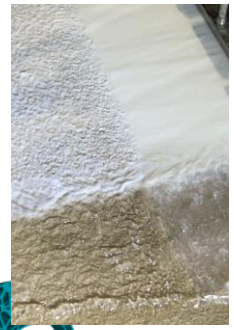
- ✓ Network bridging / film-forming
- ✓ Porosity control
- ✓ Surface hold-out



Delivered efficiently through the use of FiberLean® ultra-fine grinding technology

A breakthrough in papermaking technology
Surface application of MFC: FiberLean® on Top (FLoT)

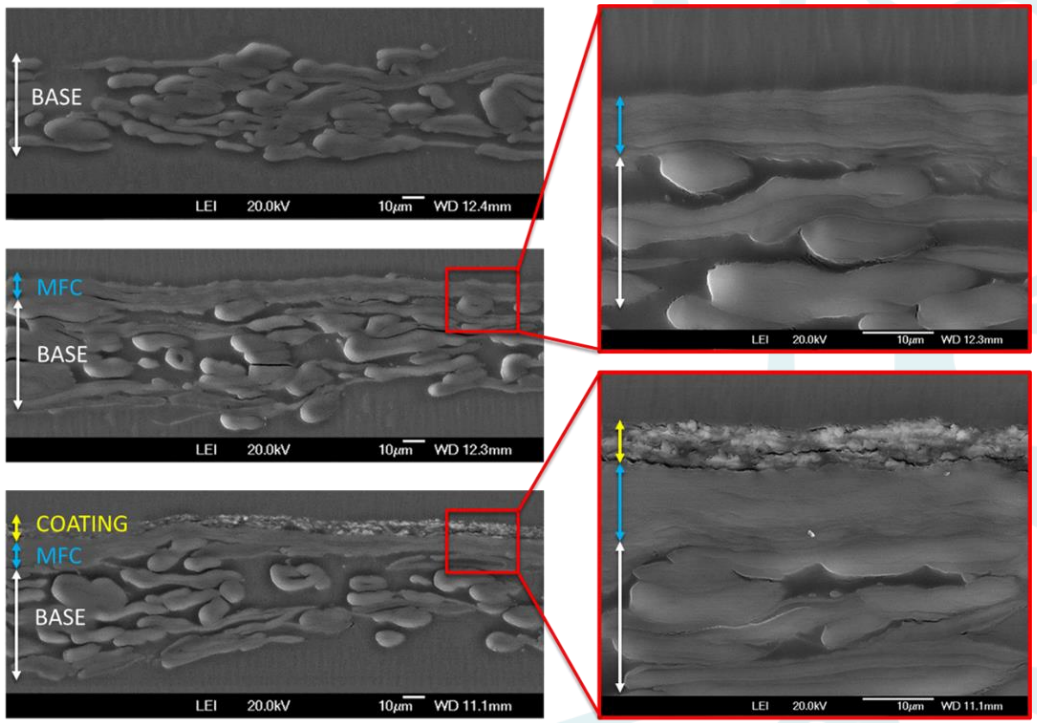
- Drain, press and dry using existing paper machine equipment.
- Low CapEx requirement.
- Convert existing production lines to new grades.
- 2-layer sheet functionality achieved with 1 forming section and no coaters.
- FiberLean are the original inventors & patent owners globally of this exciting technology



The applicator is 3,1 m wide, but width can be adjusted to suitable trim by applying water on edges.

FiberLean® MFC applied *via* FLoT provides many interesting properties for barrier products

- ✓ Oil & Grease resistance.
- ✓ Oxygen & Aroma barrier.
- ✓ Mineral oil barrier.
- ✓ Very smooth & closed surface.
- ✓ Excellent substrate for coatings.
- ✓ High-strength & durable layer.
- ✓ High bio-based content, sustainable packaging.
- ✘ MFC is **not** a water/moisture barrier.

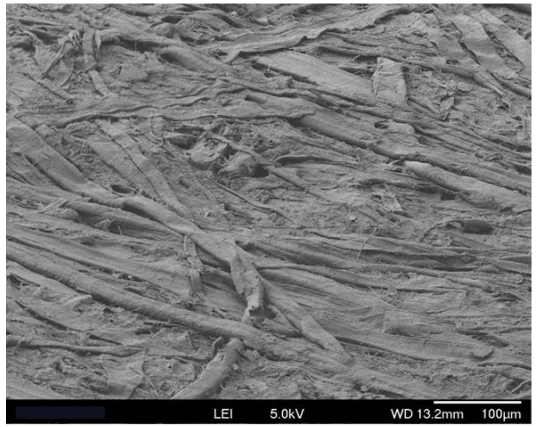


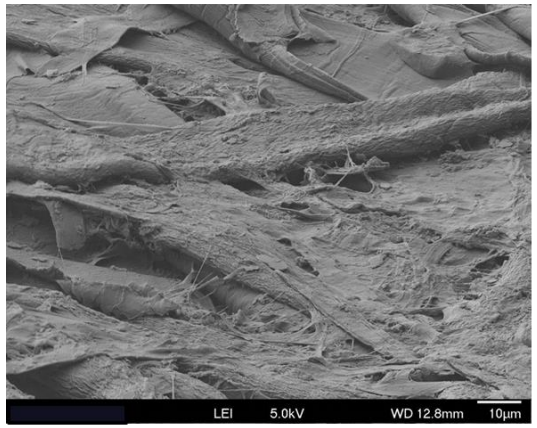
Cross-section Imaging: Scanning Electron Microscopy (SEM)

- ✓ FiberLean® MFC remains on the surface, forming a fibril-film.
- ✓ The MFC layer has a very closed structure, preventing penetration of oil and permeability of air.
- ✓ The surface serves as an excellent substrate (primer) for subsequent coatings (i.e., topcoats to achieve moisture / water barrier).

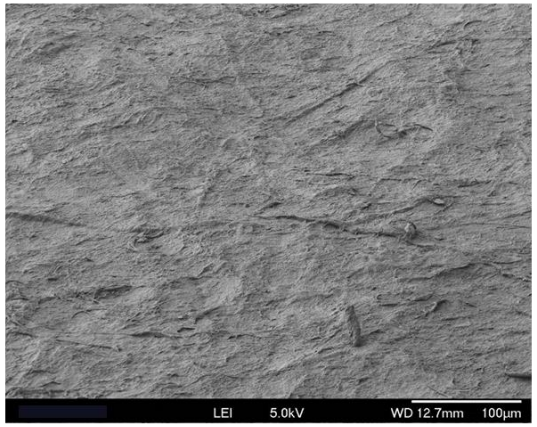
Scanning Electron Microscope (SEM) imaging
Laboratory surface application of MFC

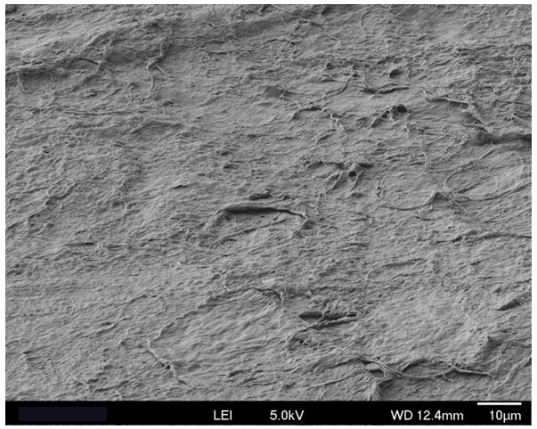
0 g/m² (No coating)



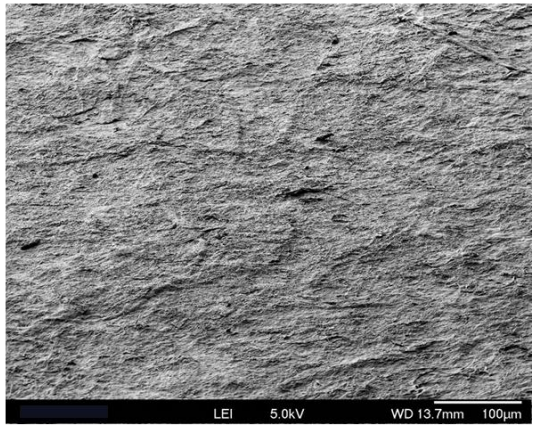


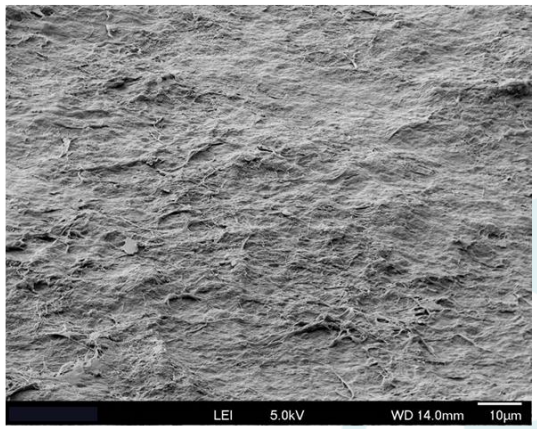
4 g/m² (MFC coating)





12 g/m² (MFC coating)

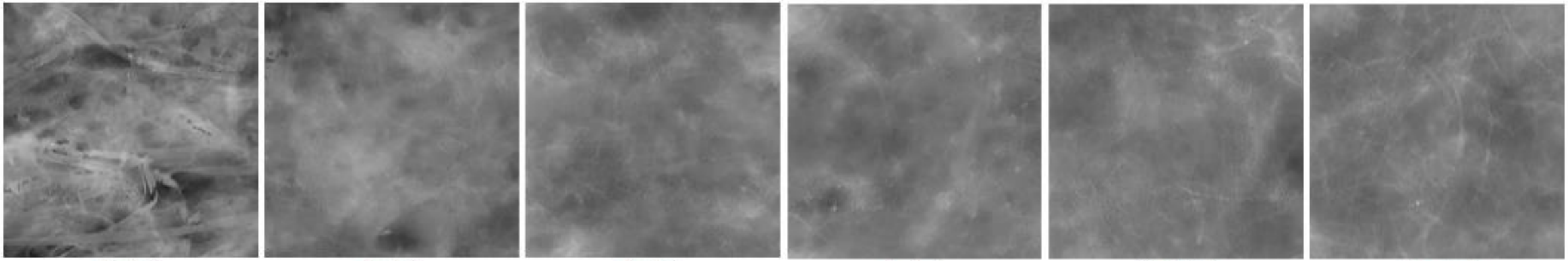


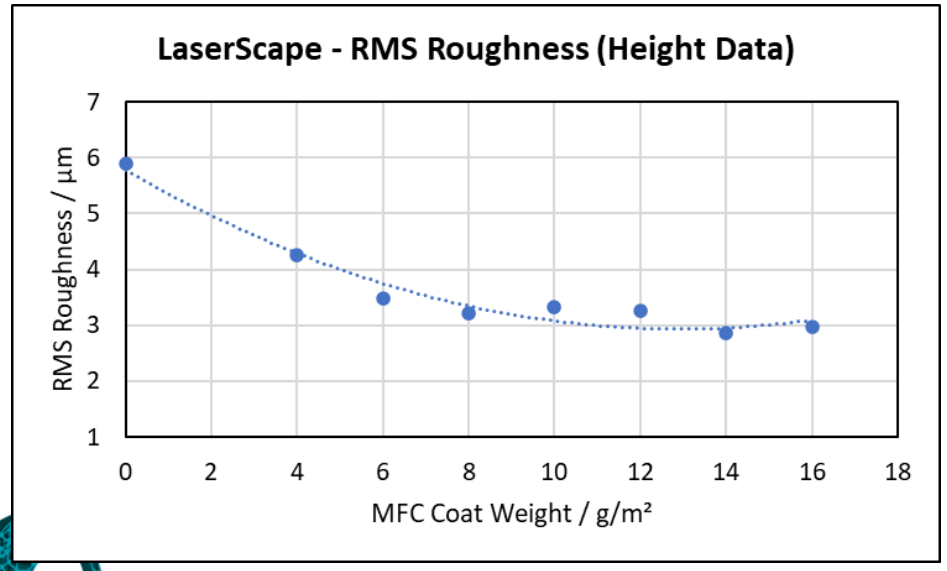


- ✓ The lowest coat weight, 4 g/m² provided substantial changes to the surface topography and structure.
- ✓ By 12 g/m², the MFC has formed a film and reached sufficient thickness to achieve high barrier properties.

Surface profilometry (LaserScape analysis)

Laboratory surface application of MFC





MFC Coat Weight	LaserScape RMS Roughness
g/m²	µm
0	5.9
4	4.3
6	3.5
8	3.2
10	3.3
12	3.3
14	2.9
16	3.0

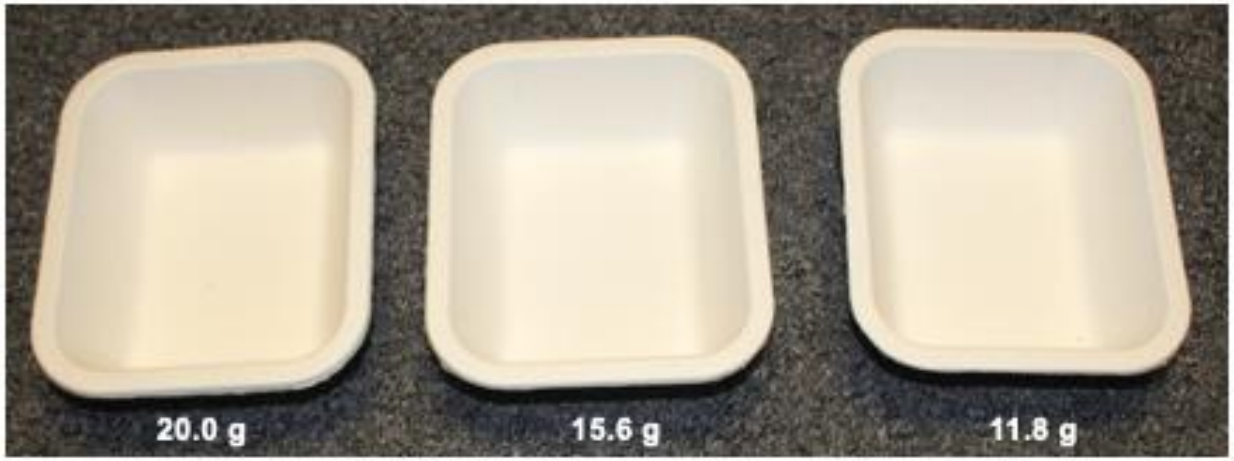
- Increasing MFC coat weight significantly improves surface roughness.
- The MFC layer serves as a film, covering the base surface contours and bridging gaps between them.

General changes to surface properties
Laboratory surface application of MFC

MFC Coat Weight	Bendtsen Porosity	Gurley Porosity	PPS Roughness 1000kPa	KIT Rating 0 = Fail 1 = Lowest 12 = Highest	n-Heptane Oil Vapour Transmission Rate (HVTR)
g/m²	ml/min	s	µm	1-12	gsm / day
0	131	91	6.4	0	1992
4	51	240	5.3	0	1479
6	14	834	5.3	0	571
8	3.0	4203	5.2	2	95
10	1.0	10843	5.1	**6**	**4.6**
12	1.0	11285	5.1	**12**	**10.2**
14	1.0	11272	5.2	**12**	**1.0**
16	1.0	11363	4.9	**12**	**0.7**

- ✓ 4 and 6 g/m² reduce permeability substantially, and improve macro roughness (PPS).
- ✓ Between 8, 10 and 12 g/m², the transition towards a barrier film occurred.
- ✓ By 10 g/m² a medium-level oil and grease (KIT), and effective mineral oil barrier (low HVTR) were achieved.
- ✓ By 12+ g/m², the highest KIT (12) was achieved and HVTR values were very low.

MFC can also be used in fibre moulding barrier applications
Mix FiberLean® MFC into the pulp stock



(0% FiberLean® MFC) KIT = 0 out of 12

(10% FiberLean® MFC) KIT = 0 out of 12

(17% FiberLean® MFC) KIT = 4 out of 12

FiberLean® MFC) Content (%)	Tray Basis Weight (g/m^2)	Tensile stiffness index ($N\ m\ g^{-1}$)	Tensile strength index ($N\ m\ g^{-1}$)	Tensile stiffness ($N\ m^{-1}$)	Tensile strength ($N\ m^{-1}$)	Bendtsen Porosity ($ml\ min^{-1}$)
0	480	2.63	21.2	1270	10.2	2750
10	**380**	**3.45**	**37.2**	**1300**	**14**	**160**
17	**280**	**5.04**	**53**	**1430**	**15.1**	**15**
25	**175**	**5.37**	**56.4**	930	**9.8**	**4**

Example data from a pilot-scale moulded object (tray) trial.

Moulded objects such as trays prepared from bleached pulp can benefit from FiberLean® MFC:

- ✓ Up to 50% reduced object weight whilst maintaining strength, stiffness and mouldability.
- ✓ Greatly improved smoothness, haptic feel and reduced permeability.
  - ➢ Improved hold-out of functional coatings applied (e.g. Barriers) and effectiveness of sizing.
- ✓ OGR barrier properties (≥30% MFC results in KIT 12).
  - ➢ Opportunity for replacement of PFAS.

Conclusions/Summary

- ✓ The exciting concept of applying MFC on top of a draining base paper was already introduced at IMPS last year.
- ✓ Since then, we have proven that it works in full-scale to make White Top Liner.
- ✓ The keys to the success are,
  - The novel design FLoT applicator.
  - MFC quality optimization.
  - The ability to make major quantities of MFC of correct quality available for trials.
- ✓ This new “FiberLean on Top” application technology can also be used to apply pure MFC for barrier purposes.
- ✓ Results in this area are very promising.
- ✓ MFC is a fantastic tool for new packaging development.