Mikrofibrilloitu selluloosa (MFC): Mahdollisuudet ja haasteet tulevaisuuden materiaalikehityksessä

Heli Kangas, Valmet

Microfibrillated cellulose (MFC) – wood-based nanomaterial

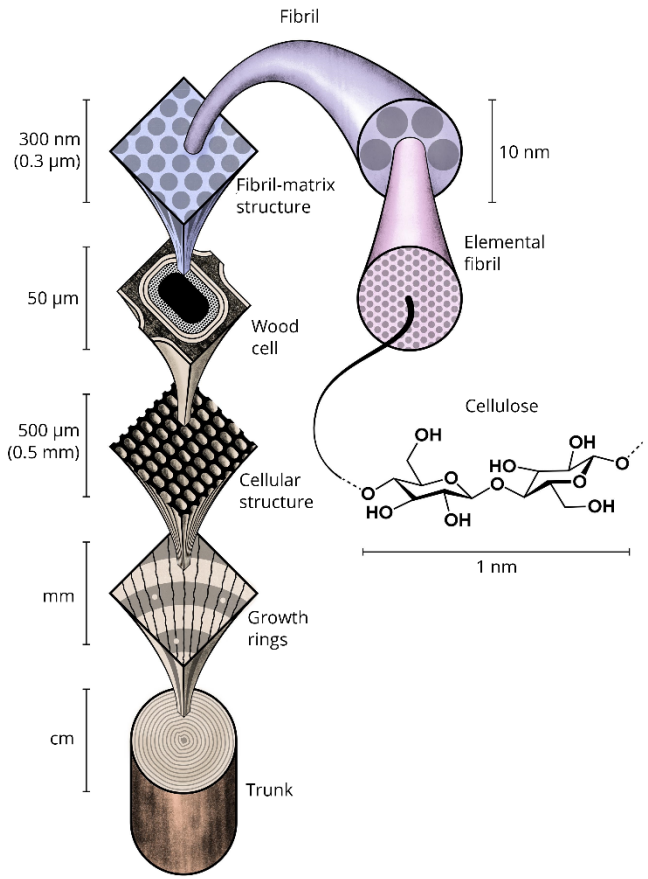
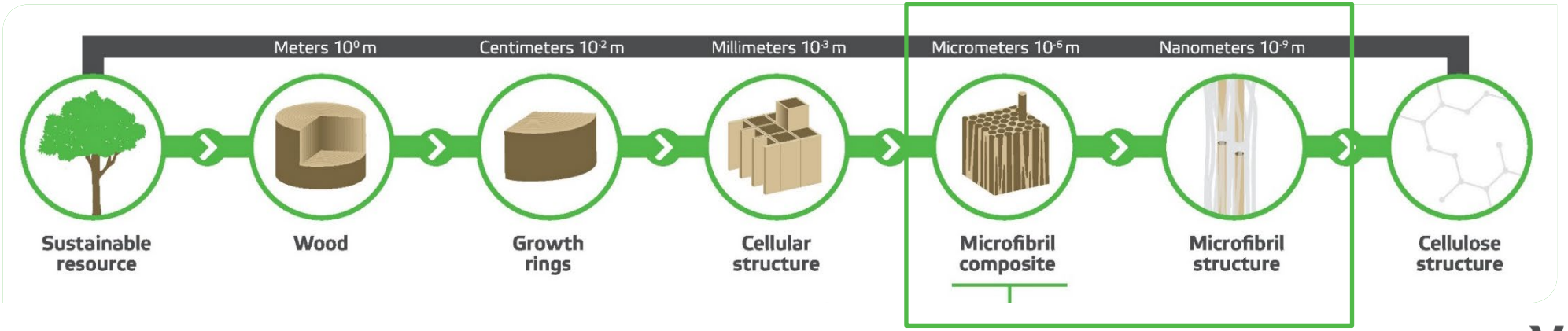


Illustration by Safa Hovila © VTT

- Width range typically
  - 20-40 nm after mechanical treatment
  - 3-5 nm after chemical pre-treatment (such as TEMPO), followed by mech. treatment
  - 5-20 nm after enzymatic pre-treatment, followed by mech. treatment
- Length several µm
- Mechanically manufactured generally heterogeneous & branched.
- Chemically pre-treated homogeneous, individualized (iCNF)
- Contain both crystalline and disordered regions
- Terms generally used
  - Microfibrillated cellulose (MFC)
  - Cellulose nanofibrils (CNF) or nanofibrillated cellulose (NFC)

What is MFC and how do we define it?

- MFC is fiber that has been highly refined using mechanical refining energy
- The level of refining is expressed as a given % Fines
  - A fine can be defined as being less than 0.2mm in length
- We typically produce pulps that are 65% - 95% total fines
- Fines level can be measured by several instruments including the Valmet FS5 Fiber Analyzer



It is difficult to estimate the MFC market as many players are in pilot phase and main commercial projects are in hands of only few players

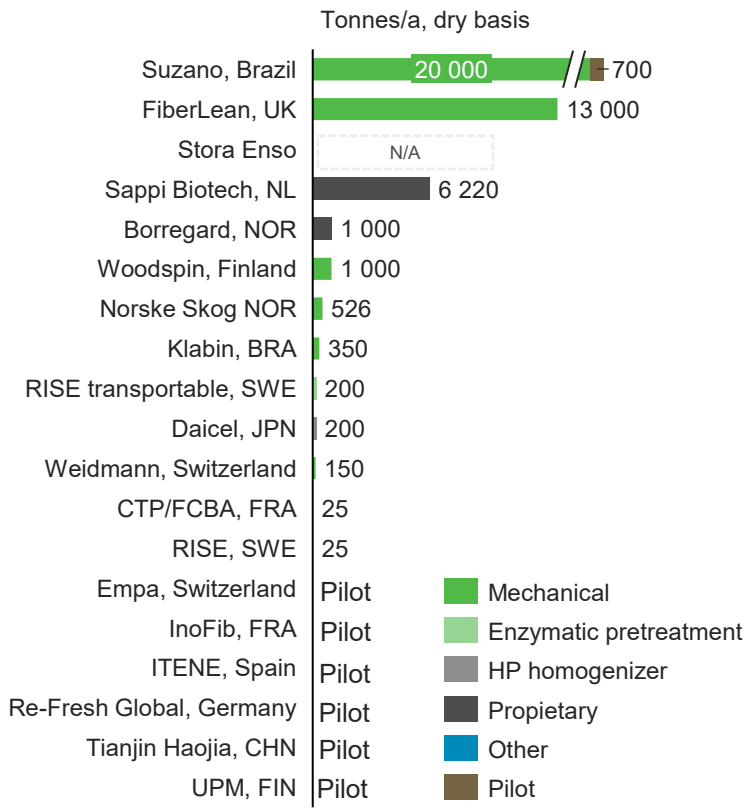
MFC market	Forecast X 2024-2031	Forecast Y 2023-2033	Actual Market ?
Market size value	Million US$ 1497.2 (2021)	Million US$ 225 (2023)	
Market size value	Million US€ 4692 (2031)	Million US$ 835 (2033)	
Growth Rate	12.1% (CAGR 2021-2031)	14% (CAGR 2023-2033) 19% China market (CAGR 2023-2033)	
Main applications	**Paints&Coatings**, Food, Paper, Packaging, Personal care, Others	**The packaging industry** forecasted to have 40% of MFC sales	
Challenges that might hinder the growth	High energy consumption during mechanical fibrillation		
Regional focus	• Asia Pacific • North America	• Nordic Countries • Investments expected in China, US and Nordic Countries	

Source: Business Research Insights, Fact.MR

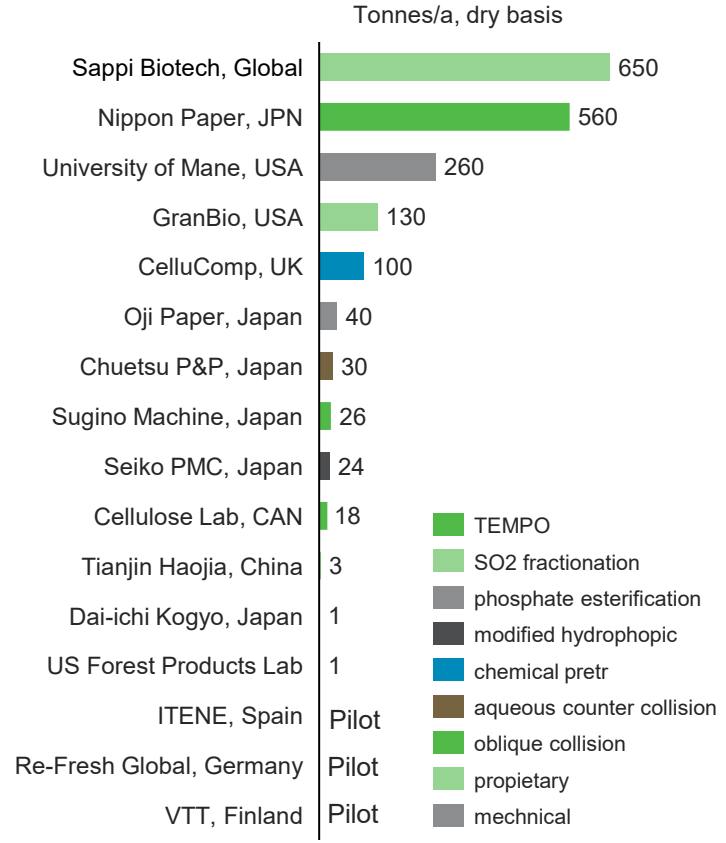
Key players in MFC and CNC

Commercial phase producers have taken a step forward, more pilots coming to market

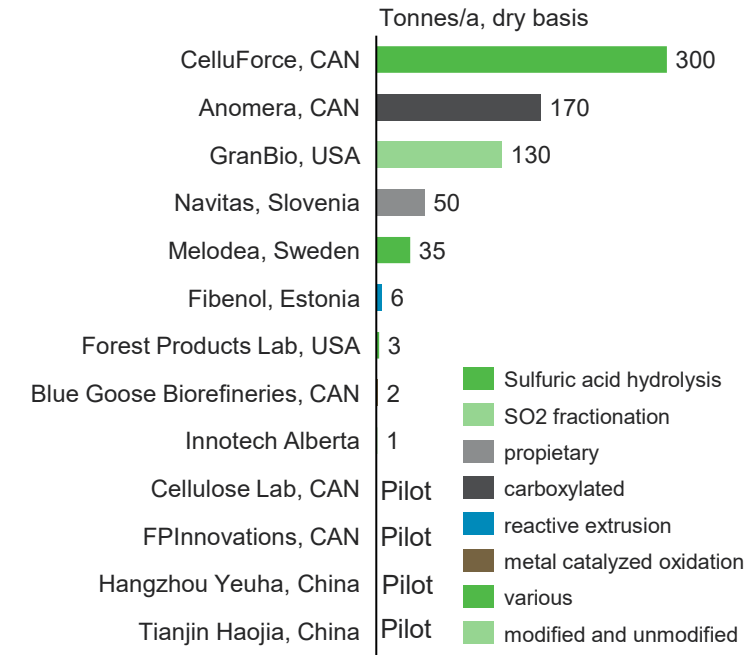
MFC Producers



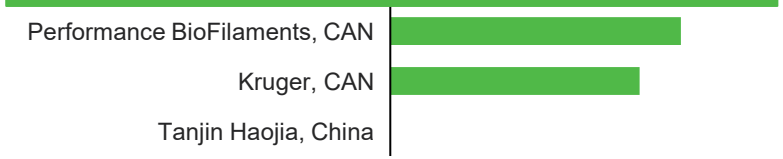
CNF Producers



CNC Producers (excl. MCC)



Cellulose nanofilaments



Source: Valmet internal, TAPPI, Jack Miller (Principal Consultant, Biobased Markets)

Sustainability and regulatory issues e.g., plastic replacement drive the demand

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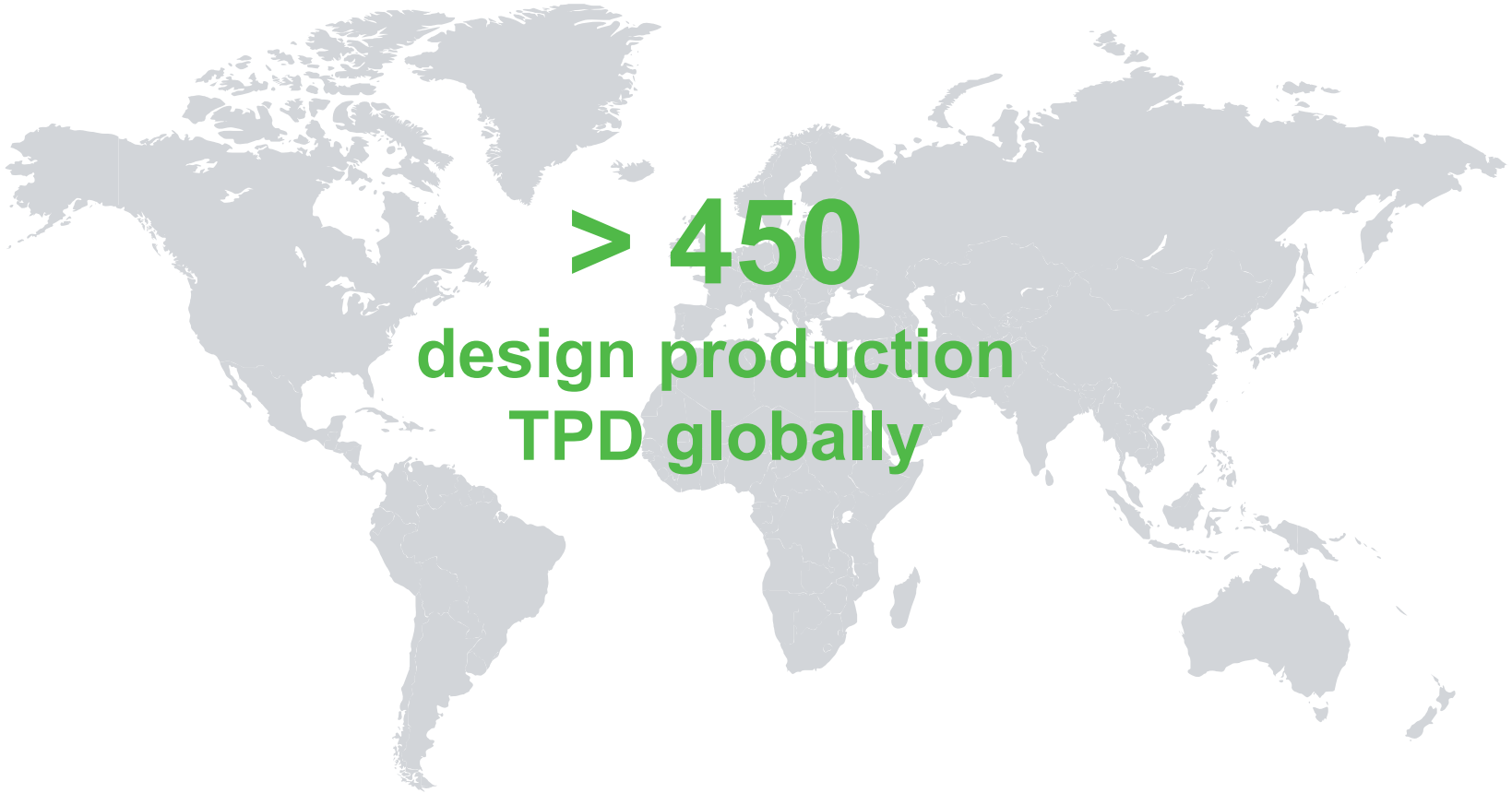
Growth Rate	12.1% (CAGR 2021-2031)	14% (CAGR 2023-2033) 19% China market (CAGR 2023-33)	Current players are mainly from Europe, North America and Japan – Growth in China?
Main applications	**Paints&Coatings**, Food, Paper, Packaging, Personal care, Others	**The packaging industry** forecasted to have 40% of MFC sales	
Challenges that might hinder the growth	High energy consumption during mechanical fibrillation		High energy consumption - true or false? Valmet can offer energy efficient solutions
Regional focus	• Asia Pacific • North America	• Nordic Countries leading the demand for MFC • Investments expected in China, US and Nordic Countries	Investments in China?

Source: Business Research Insights, Fact.MR

Valmet MFC Lines references

Over 20 MFC lines delivered from 2013



GRADE TYPES

Board	Non-paper
Tissue	Specialty
Mix	Research
MFC Pilots	

WOOD SPECIES

Hard wood

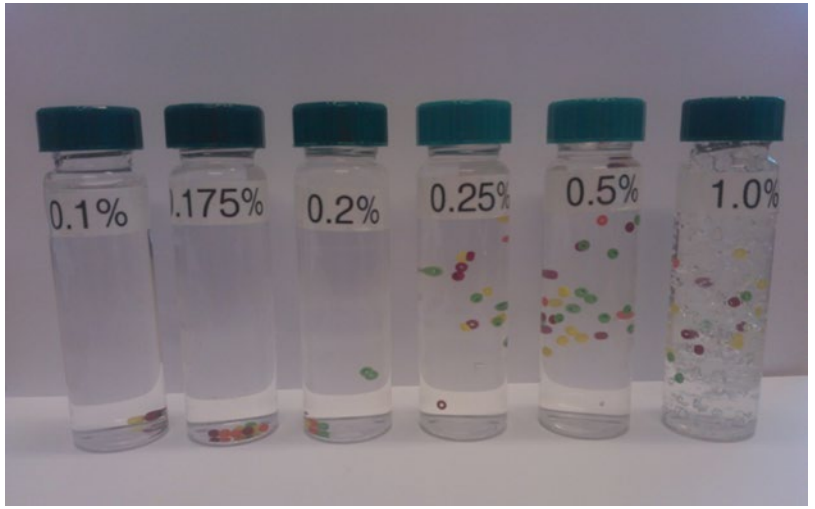
Soft wood

OCC

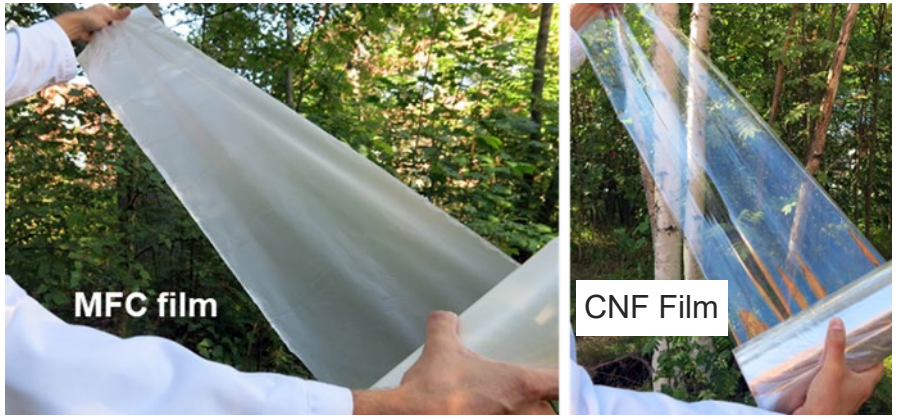
Broke

Unique properties of MFC

- High specific surface area, 100-200 g/m^2
- High aspect ratio (length / width), 100-150
- Potentially high strength and modulus
- Good elastic properties
- Chemical reactivity e.g. towards functionalization
- Rheological behavior – gel formation, shear thinning, yield stress
- Film formation upon drying



Kangas, ForestBiofacts 2020 ForestBioFacts



Kumar, ForestBiofacts 2020 ForestBioFacts

Examples of MFC end uses

Versatile end uses in which properties and specific features of MFC are utilized

Paper & board, Non-woven

- Strength, light-weighting
- Replacement of chemicals in corrugated board

Films, textiles

- Gas barrier
- Modified barrier films
- Spinnova: textile fibres

Adhesives & Coatings

- Rheology & strength additive

Pharma & medical

- Pharmaceuticals
- Wound care
- Medical labs

Composites

- Fiber composites
- Strength additive in polymer mixtures

Cosmetics

- Multifunctional additive, e.g. dry-out time, viscosity & stability adjustment

Agricultural chemicals

- E.g. wetting agents
- Dry-out time additive

Construction

- Strength additive
- Rheology & performance additive

Home Care

- Performance additive
- Dry out time, dispersing, viscosity additive
- Surfactant

Electronics

- R&D phase
- Flexible electronics, replacement of fossil gels in Li-Ion batteries

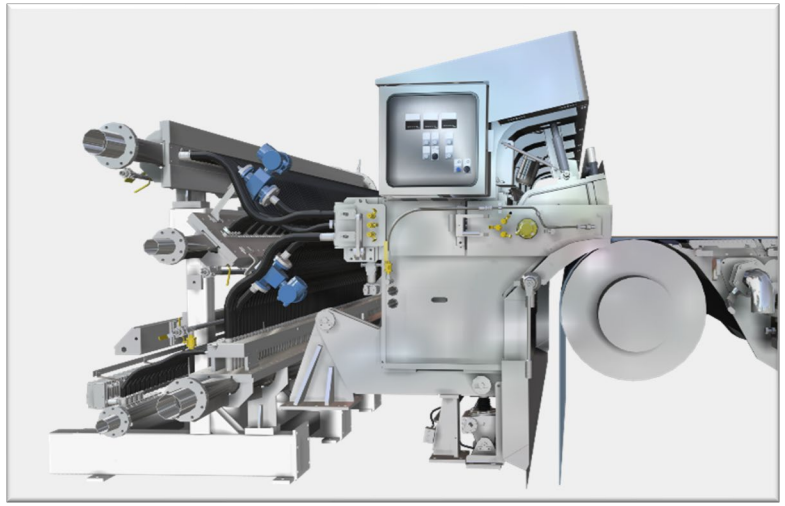
Source: Google pictures, Stora Enso, Borregaard, UPM

Paper & Board, Packaging

Valmet Technologies – MFC Application

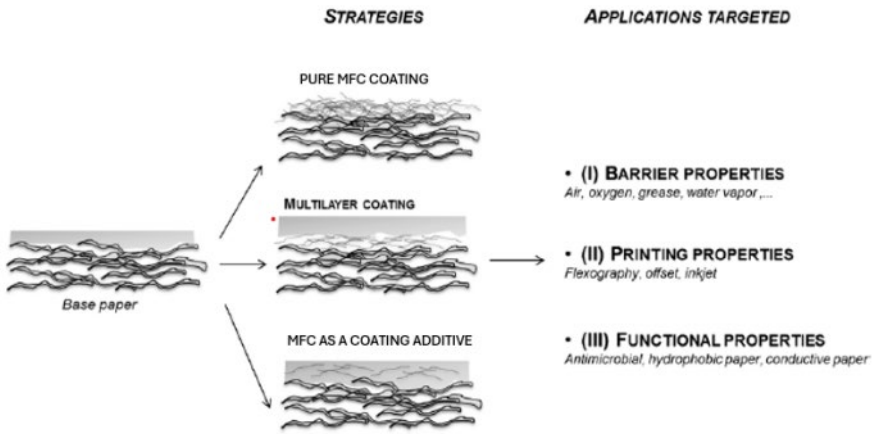
MFC Application

- Headbox technology eg. Aqua layering
- Internal Application
- Valmet Wet End Applicator
- Sizing and coating technology for surface applications



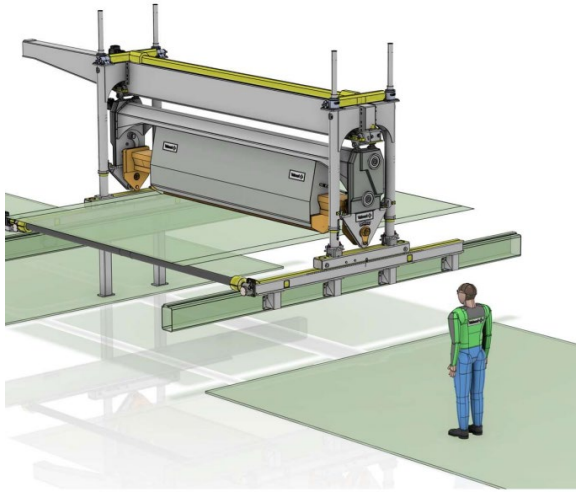
Source: Valmet internal

Coating of MFC



Anttila, K. (2023). MICROFIBRILLATED CELLULOSE AND ITS APPLICATION IN PAPER OR BOARD PRODUCTION. M.Sc. Thesis. LUT University.

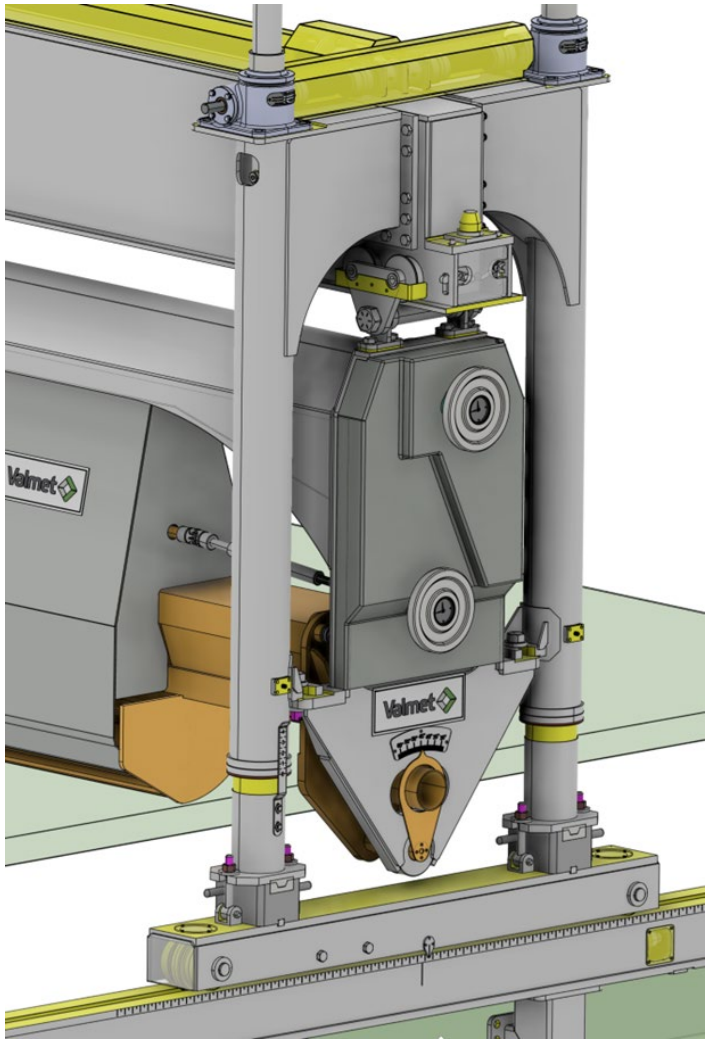
Valmet Wet End Applicator



- Application of MFC
  - As a pure coating on paper or board
  - As a pre-coating layer on paper or board
  - As an additive in coating color production
- Influencing factors:
  - Coating position – wet end, size press, coating station…
  - Coating technology
  - Retention
  - Substrate
  - MFC properties
  - Additives
  - Processing after application – dewatering, drying.

Valmet Wet End Applicator

- The Valmet Wet End Applicator is mounted above the wet end wire section of the paper machine.
- The MFC is forced out of an adjustable narrow slot as a jet, onto the wet stock.
- The Wet End Applicator can easily be retrofitted to existing paper and board machines and can provide uniform coverage and good CD distribution with MFC and other additives.



Wet End Applicator for surface MFC application

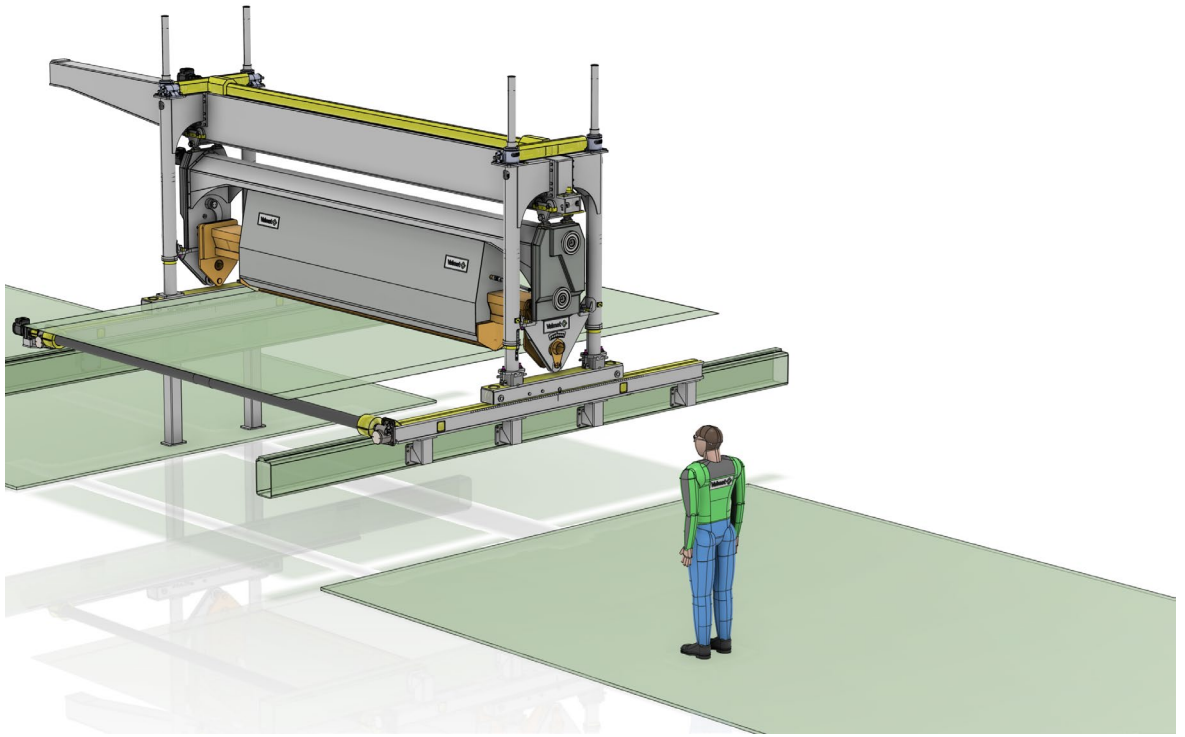
Surface applied MFC can develop barrier properties without use of fluorochemicals or polymers.

Surface MFC acts as a pre-coat allowing coated grades to be produced with lower coat weight.

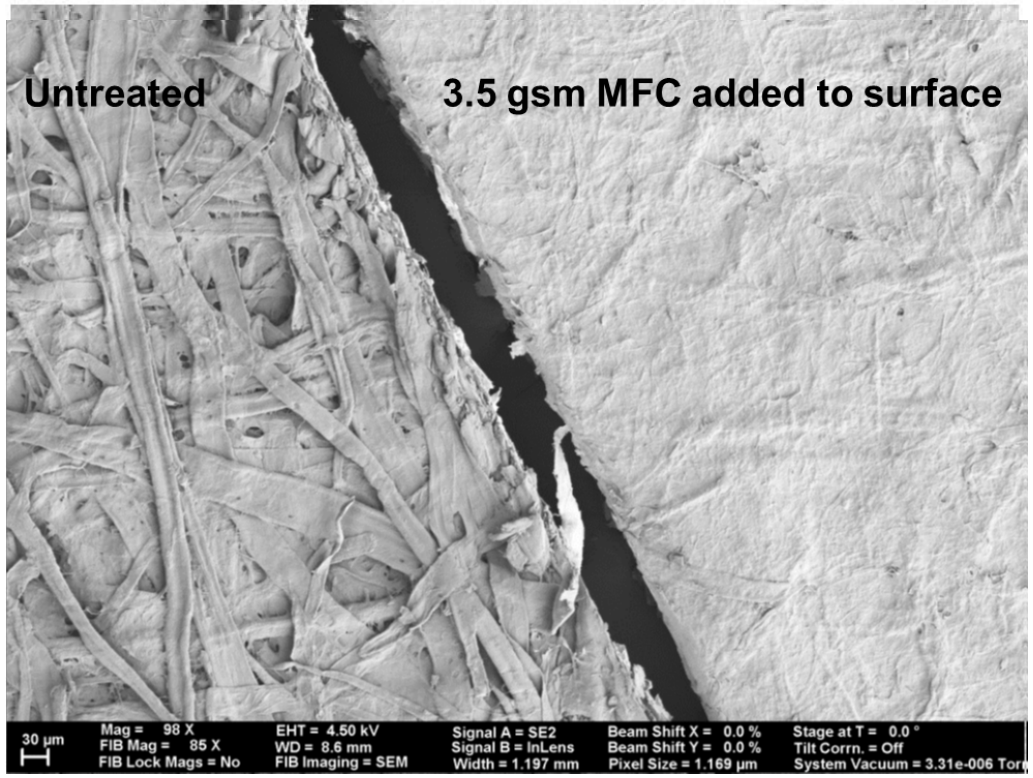
MFC can be applied alone or in combination with starch, and other additives.

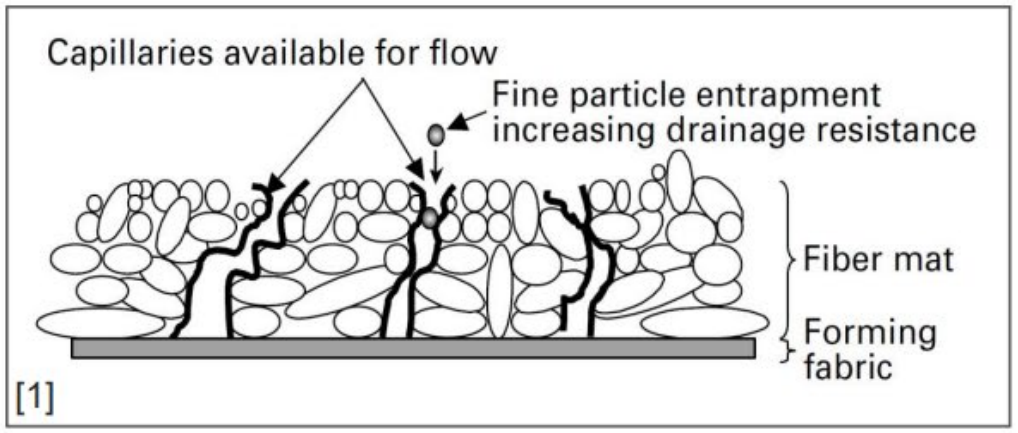
Grades include packaging, graphics, release, food contact, and specialty papers.

We offer in-mill and pilot facility trials.



MFC Surface Application

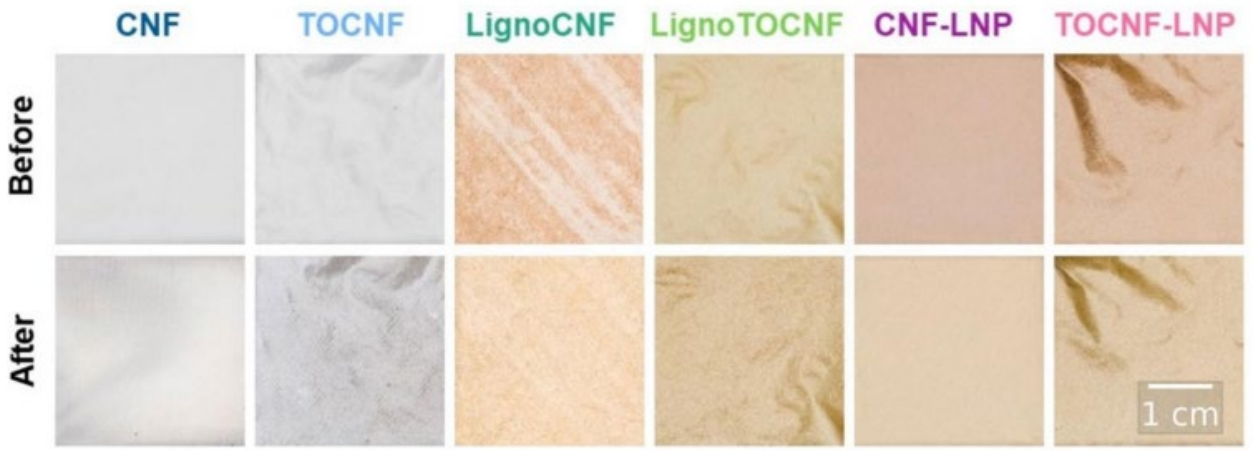




MFC films

- Production of MFC films separately and lamination into paper/board substrate.
  - Filtration
  - Cast coating
- Appearance of films depends on the MFC quality
  - Transparency / -lucency
  - Color
  - Barrier performance

Surface Coating (SutCo) pilot line at VTT for preparing MFC films.



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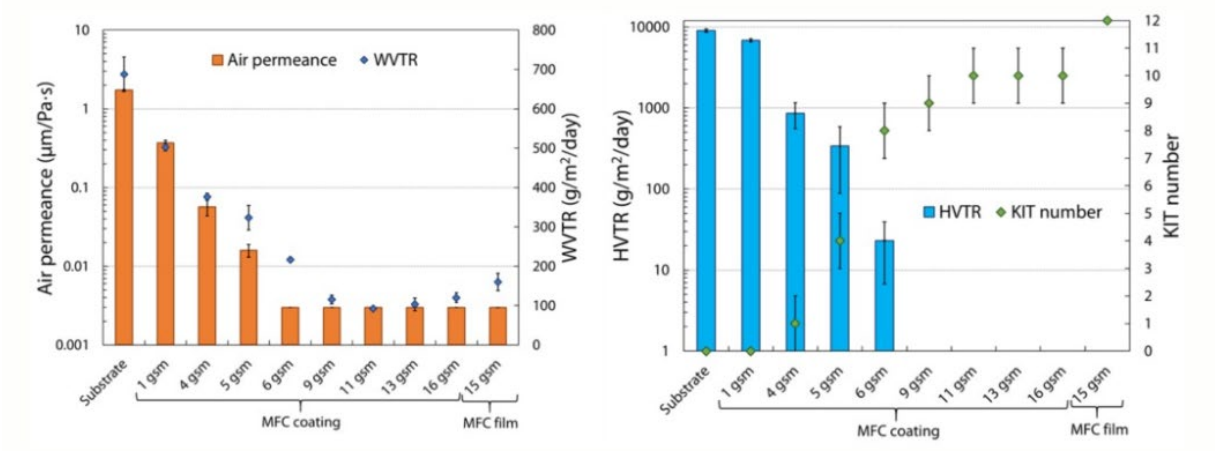
MFC in coatings and as films

- Benefits
  - Good oxygen and grease barrier properties
  - Low coefficient of thermal expansion
  - Optical properties – translucent / transparent
- Challenges
  - Compromised barrier to water vapor, especially with increased humidity
  - Cracking
  - Delamination
- Strategies to overcome challenges
  - Chemical modification of MFC
  - Use of plasticisers, waxes, additives
  - Layered structure



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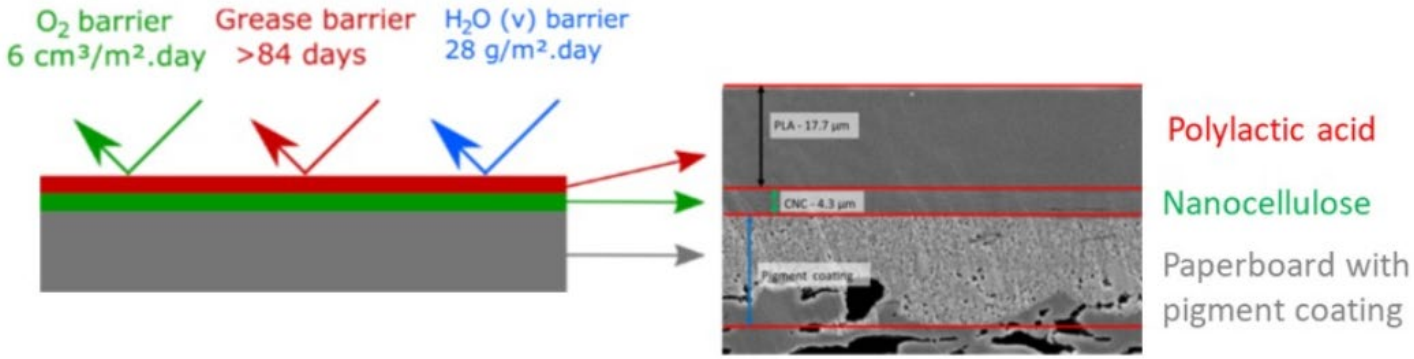

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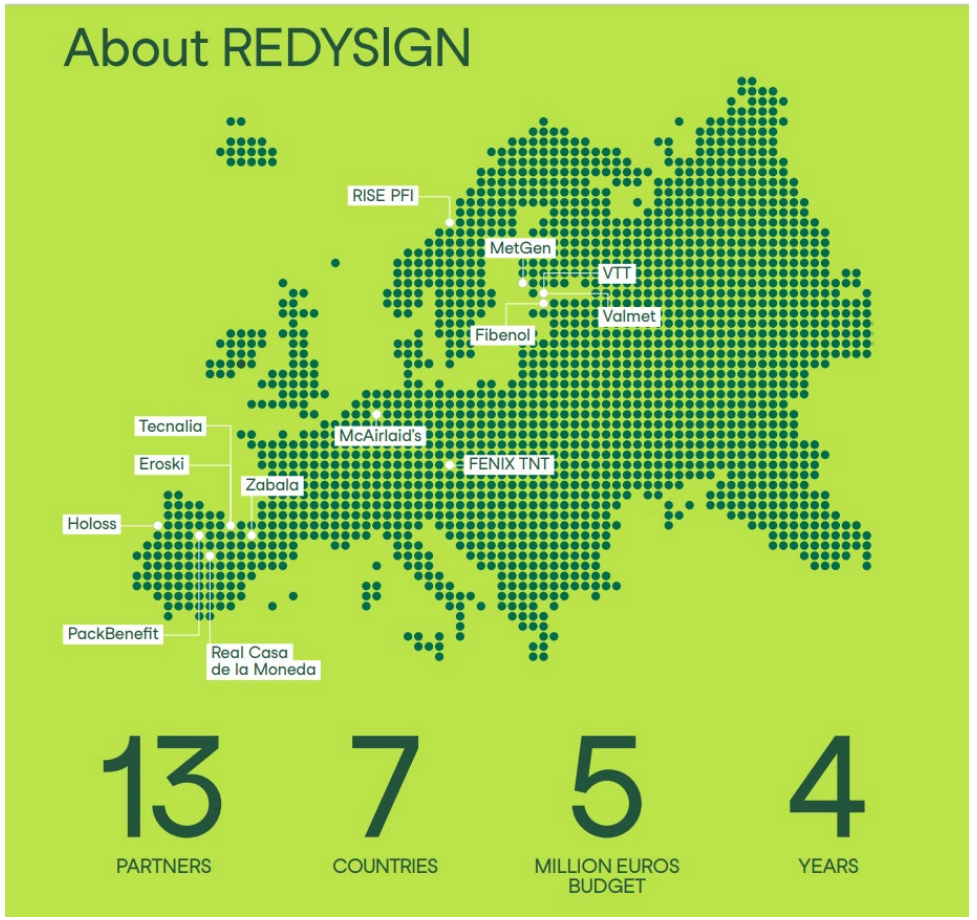
REDYSIGN

Resource-efficient processes for the production and circularization of innovative RECYclable-by-DeSIGN fresh meat smart packaging from wood

- Coordinated by Tecnalia (ES), funded by European Commission under the Horizon Europe frame programme and Circular Bio-based Europe Joint Undertaking.
- 4 fields of development
  1. Efficient processes to transform wood into Fiber-based packaging
  2. Fresh food packaging from wood-derived products
  3. Technologies to enhance smart food packaging
  4. Efficient recycling and upcycling technologies for contaminated Fiber-based packaging
- Valmet's role: Development of conical refining process by designing new refiner segments for low energy MFC production, target is 0.5 MWh/t.



REDYSIGN: biobased fresh meat packaging

Textiles

Spinnova

With Spinnova technology, the pulp raw material is mechanically refined and transformed into spinning-ready fibre suspension without harmful chemistry — no dissolving, no regeneration. Spinnova technology is the only process in the world that converts cellulose into textile fibre in this way.

Upon spinning into filament, the suspension flows through a unique nozzle at a high pressure. The right extrusion causes the fibrils to rotate and align with the flow to create a natural textile fibre. The fibre is then simply dried, collected and post-processed, ready for spinning into yarn.

Spinnova. Cleanest process. Disruptive circularity. | Spinnova

Valmet

SPINNOVA® FIBRE

SPINNOVA® is a novel fibre which is blended with other preferred fibres to make yarn and fabrics. The fibre can be integrated into innovative and conventional textile processing methods, such as those used in cotton processing.

The fibre properties, look, and feel are comparable to those of natural cellulosic fibres, such as cotton, while reducing odour intensity compared to cotton. SPINNOVA® fibre can be produced from wood pulp or waste, such as leather, textile, or agricultural cropping waste, without harmful dissolving chemicals.

Spinnova. Cleanest process. Disruptive circularity. | Spinnova

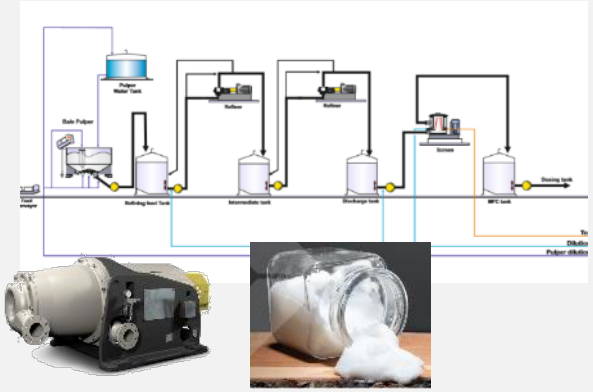
Summary – Opportunities and challenges

- MFC has unique properties and potential for many applications.
- Can be prepared from many cellulose-containing raw materials besides wood
  - Non-wood materials are becoming more of an interest, e.g. agro-based, industrial side streams, textile waste
- Production is still of interest – Valmet is supplying big lines to its customers.
- Scope of applications is expanding.

- Market
- Logistics
- Investment & production costs
- Benefit vs cost – green / sustainable material is not enough by itself.
- Material properties not adequate for certain applications
- Lack of standardized methods for characterization
- Approval for novel end uses

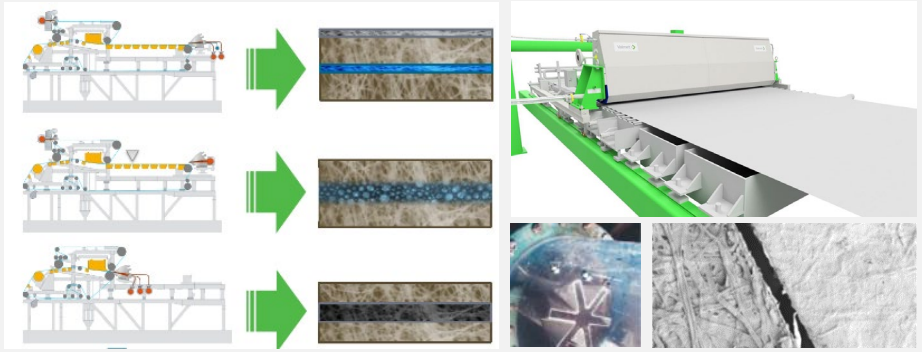
Valmet´s MFC offering

One supplier for complete production and services



Production lines for multiple end uses

- Concepts
- Key technologies
- Industrial Internet



Application to board, paper and tissue

- Approach flow system mixing solutions
- Head boxes and drying solutions
- Wet and dry end application technologies

Drying technology for textile filaments

Analyzers

- Analyzers for lab and online measurements

Services

- Fillings
- Refiner upgrades

Piloting in Technology Centers and on the sites

- Fiber technology centers: Inkeroinen, Tumba, Sundsvall
- Paper technology centers: Rautpohja, Järvenpää and Karlstad

Valves & Special pumps


Valmet
FORWARD