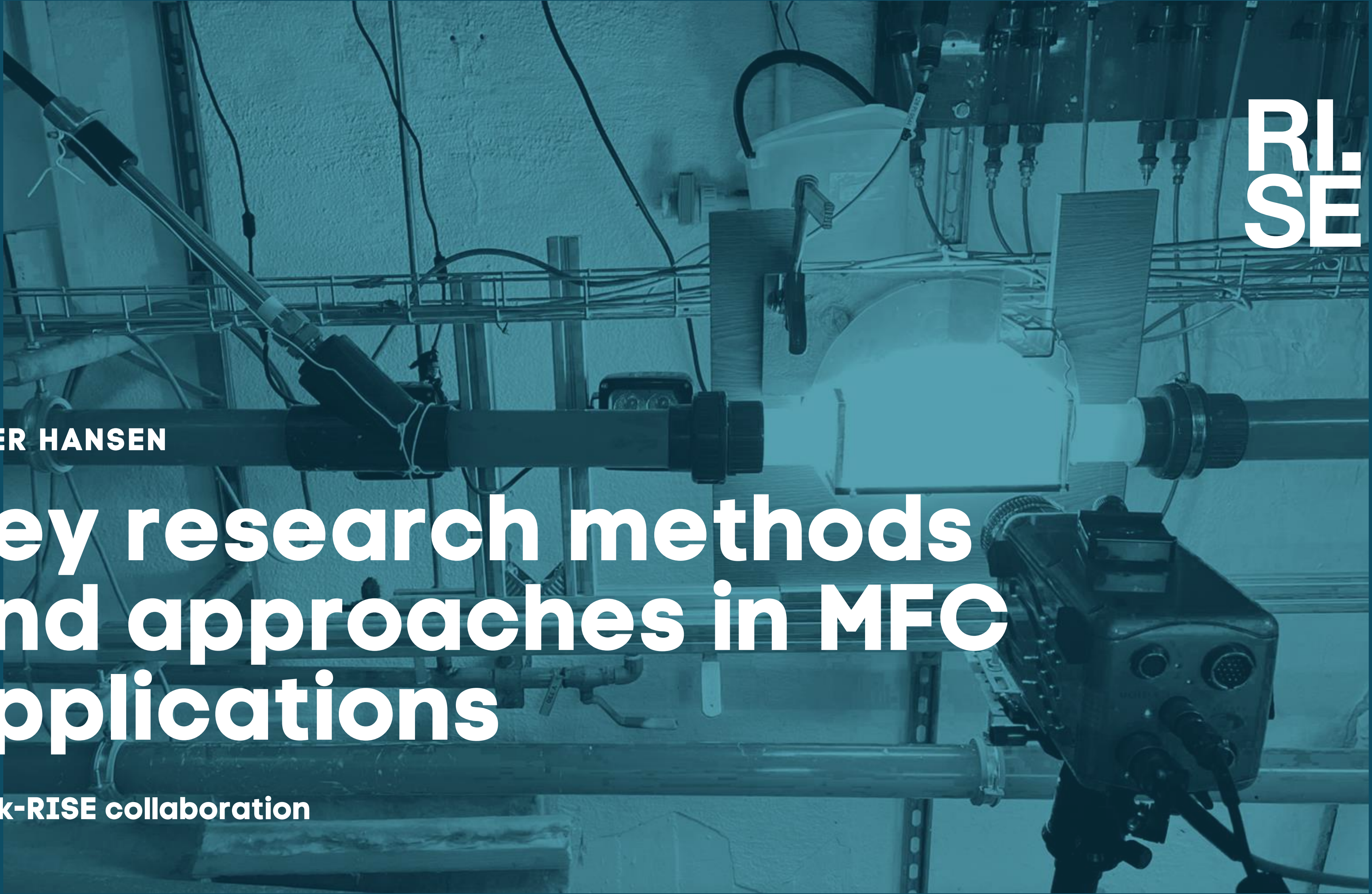


PETER HANSEN

Key research methods and approaches in MFC applications

Xamk-RISE collaboration

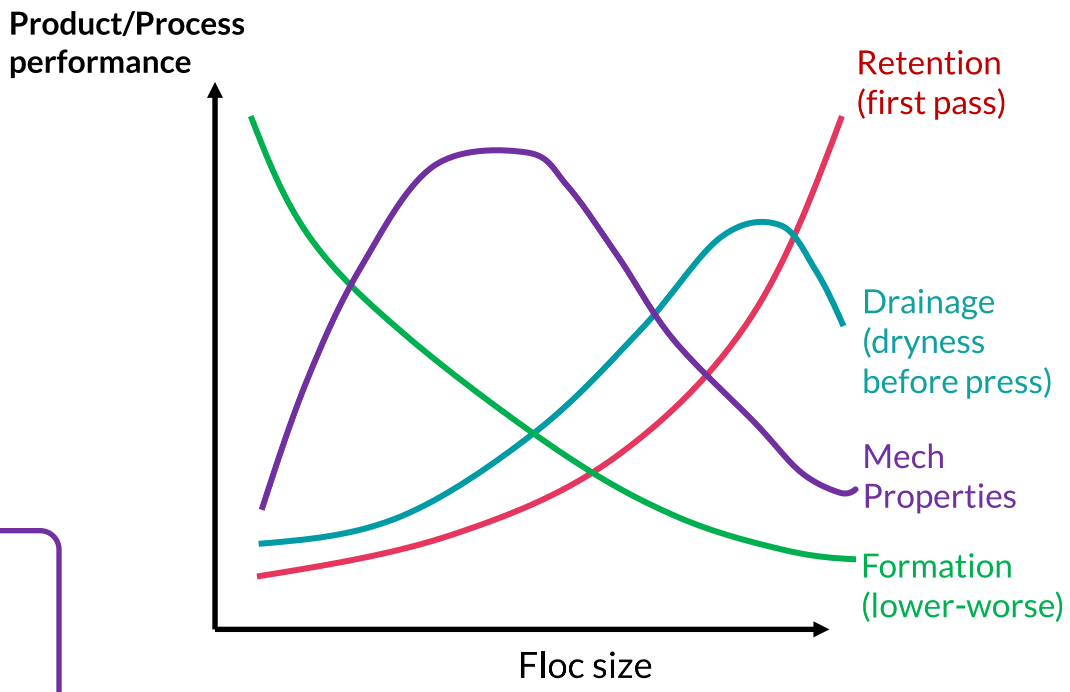
Wet-End optimization

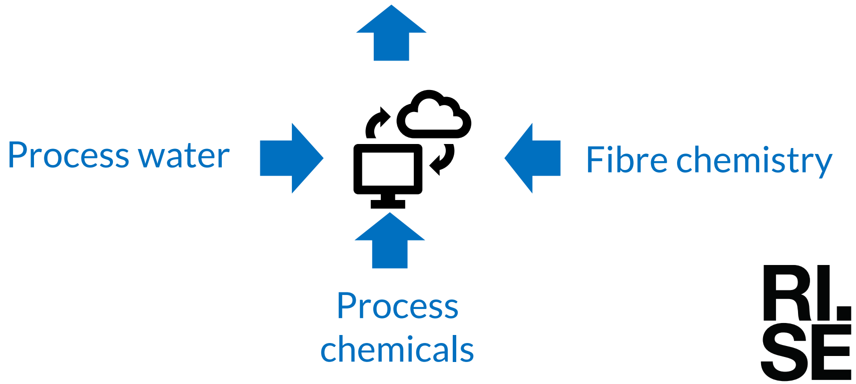
Wet-end 1.0
- Retention and Dewatering

Wet-end 2.0
- + Formation, total retention, press efficiency

Wet-end 3.0
- + Mechanical properties, strength strategies, coagulation (wet-end starts on the thick stock)

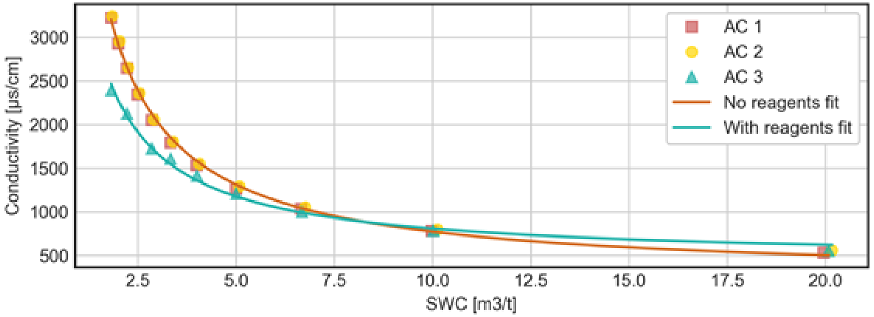
Wet-end 4.0:
- + Process chemistry control (Incl Fiber and Process Water).
- + Implementing flocculation soft sensors and predictive tools



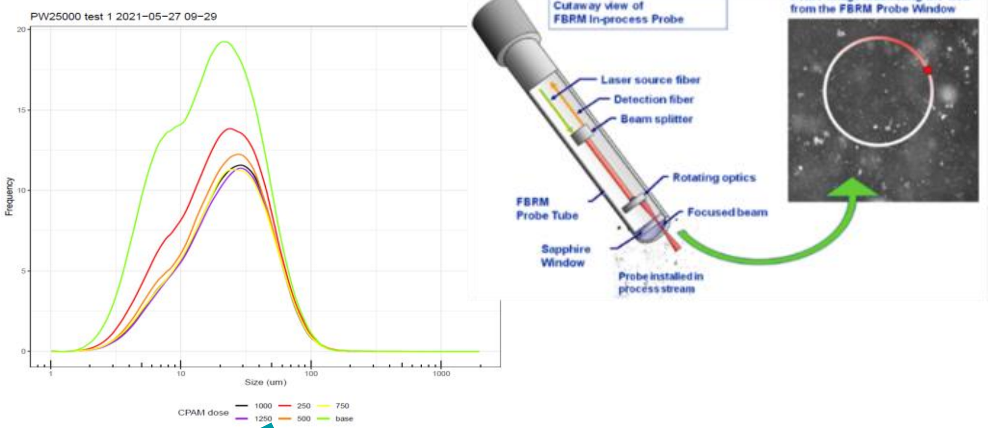


Wet-end 4.0

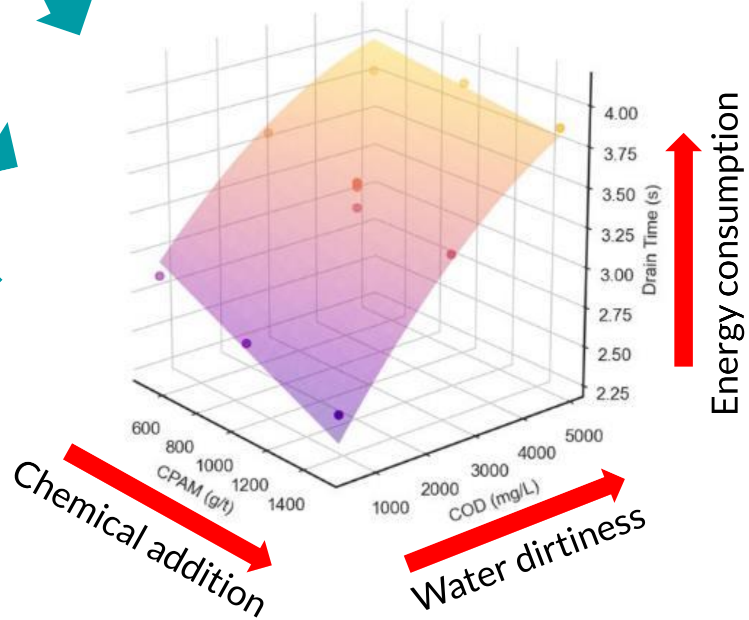
Investigation on process water conditions

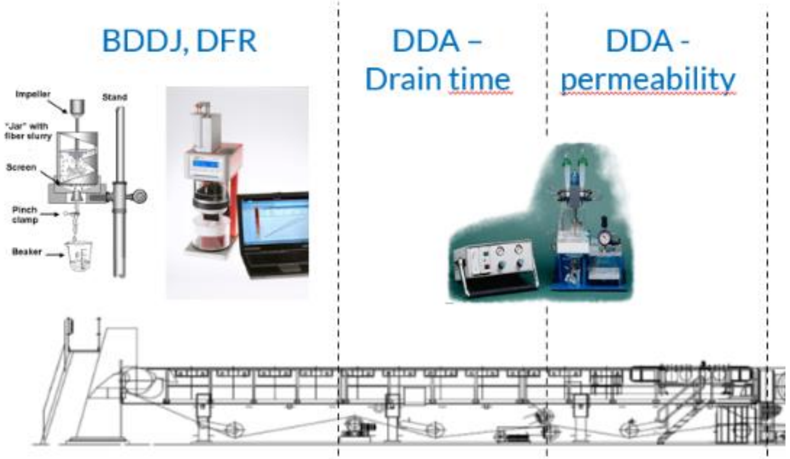


Flocculation studies



Integrated analysis





Wet-end efficiency analysis

MFC in Papermaking applications

Boosting product performance

- Synergies between MFC and other strength additives
  - Exploit the high surface area and charge of MFC
  - Effect with different starch qualities and/or polyelectrolyte forms, e.g. CPAM
- Fiber Pre-treatment
  - Carboxymethylation
  - Grafting

Improved retention & dewatering

- Controlled MFC-fiber-water interaction by balanced chemistry
  - Micro particle or low Mw additive for improved MFC retention and web dewatering
  - High charge density dewatering aids
- Sheet structure design to minimize web sealing effect
  - Optimized retention system
  - Controlled retention for optimal ZD distribution

Process Waters

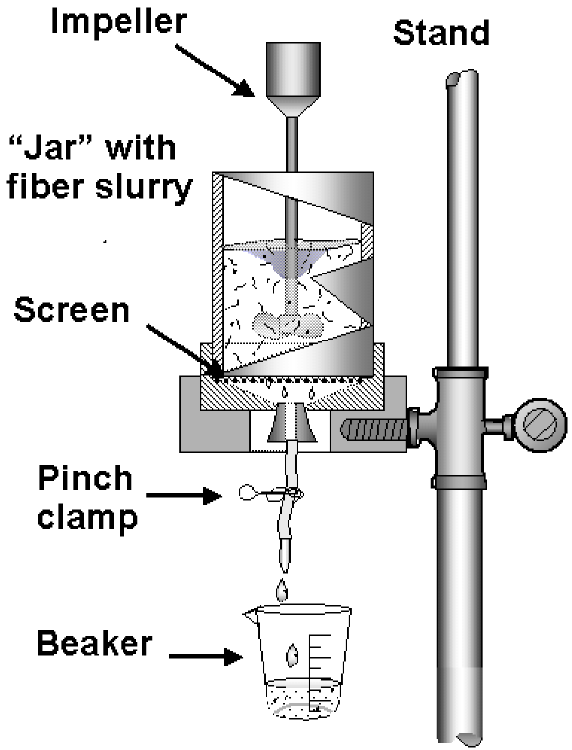
- Effect of process water quality on strength strategy
  - Effect on wet end chemistry performance
  - Simple strategies to minimize impact
- Water treatment
  - Laboratory evaluation of different water treatment strategies

Methods used by RISE for wet-end chemistry investigations

- More conventional
  - Retention of fines by DDJ (Dynamic Drainage Jar)
  - Z-potential & Cationic demand
- Less conventional
  - Dynamic drainage analyser, DDA
  - Dynamic sheet former
  - FBRM, Focused Beam Reflectance Measurements
  - High-speed imaging
- In house
  - DSSP method , distribution of fines/MFC in the thickness direction of a sheet
  - Flocculation studies in a flow loop
  - (Pilot paper machine trials)

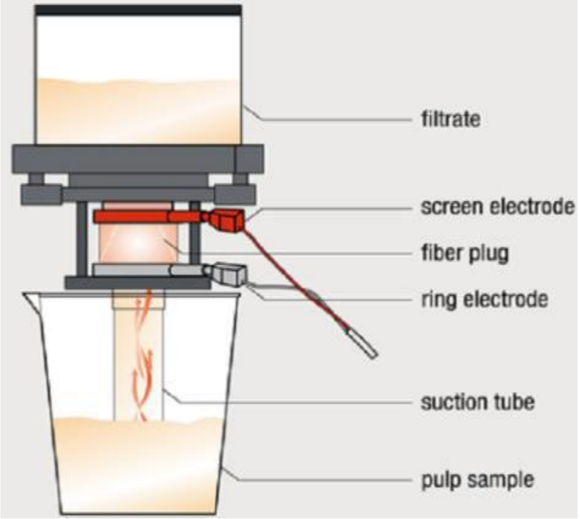
Chemical retention

- The weight of fines passing thought a screen in proportion to original weight of fines in the pulp
- Measurements done under continuous stirring



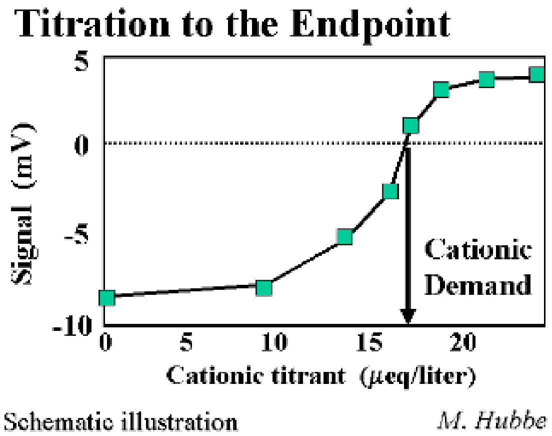
Pulp Z-potential

- Z-potential is a relatively common measurement in colloidal chemistry.
- For fibre applications, systems are designed such that the charges on the fibre are measured indirectly.
- The systems measures the streaming potential through a fiber plug (retained by a mesh).
- Many studies have found clear links between the Z-potential and the behaviour of strength additives (correlation with the amount of additive that can be added to a given pulp).
- Z-potential will change with the fibre surface, the fibre size and the conductivity of the waters.



Cationic demand

- The amount of a cationic polyelectrolyte needed to neutralize the potential of the particles present in a suspension. (fibres are removed)
- Measurements of the streaming potential are combined with titration
- The suspension must be under movement to measure the streaming potential. This is achieved by a piston.
- It has been shown that the cationic demand is closely correlated with the efficiency of flocculants and coagulants in any kind of process water treatment.



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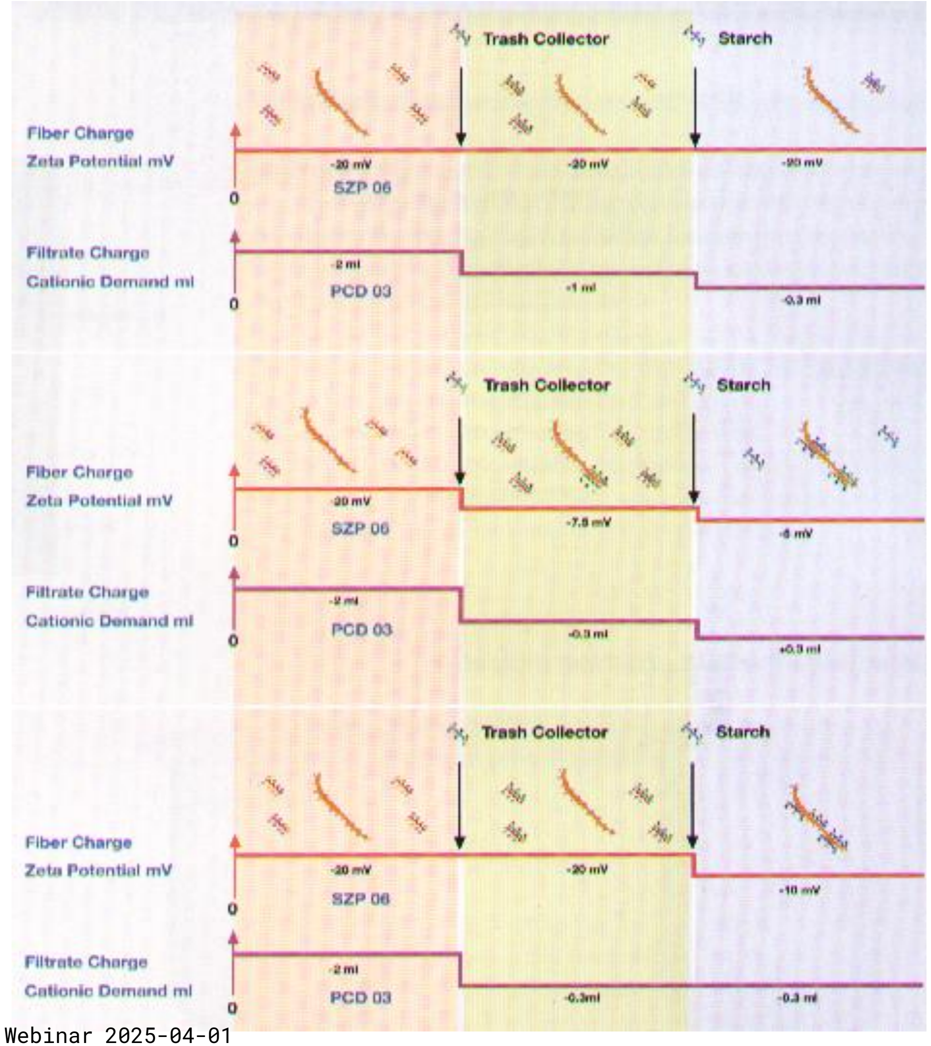
Combination of Cationic demand and fiber Z-potential



Not enough fixative to fixate all A-trash

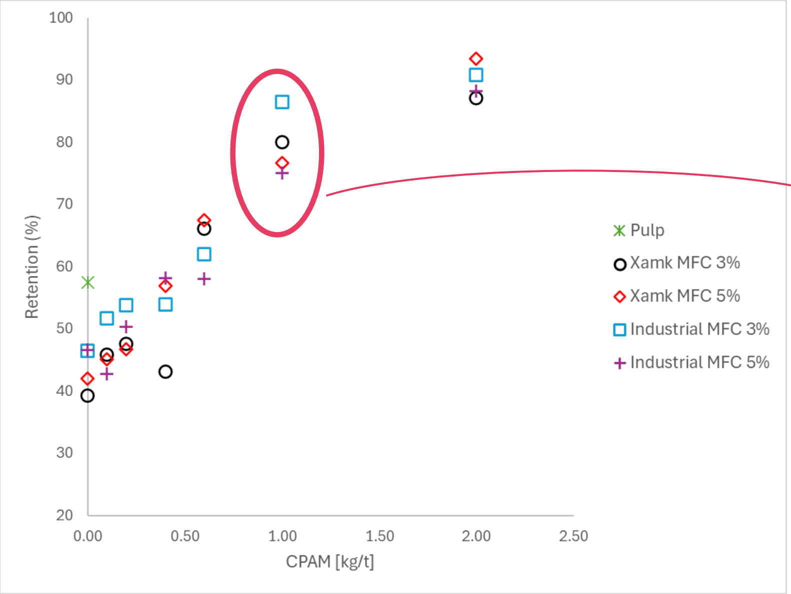
To much fixative the fiber charge is also affected

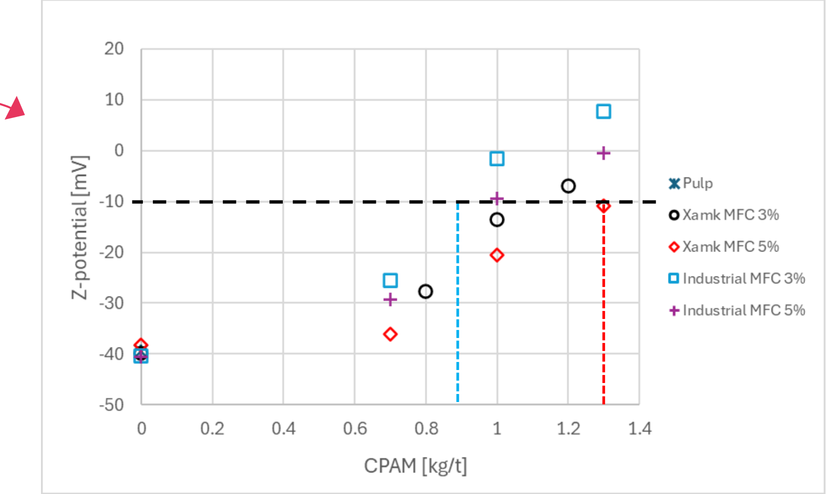
Right amount of fixative
The starch will bind to
the fiber

Example

Xamk-RISE collaboration

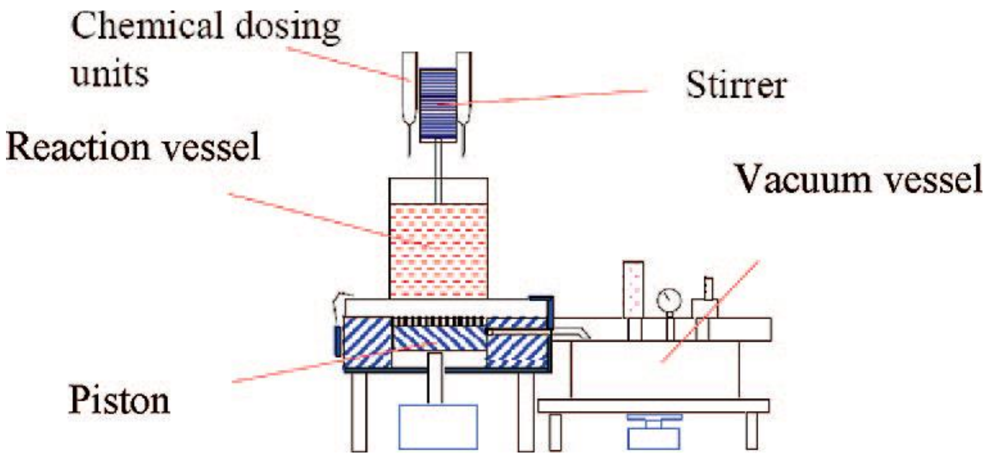
- Compare the effect of MFC qualities on paper strength and dewatering
  - MFC retained to similar degrees and
  - Adjust to similar levels of Z-potential to provide similar opportunities for dewatering agents

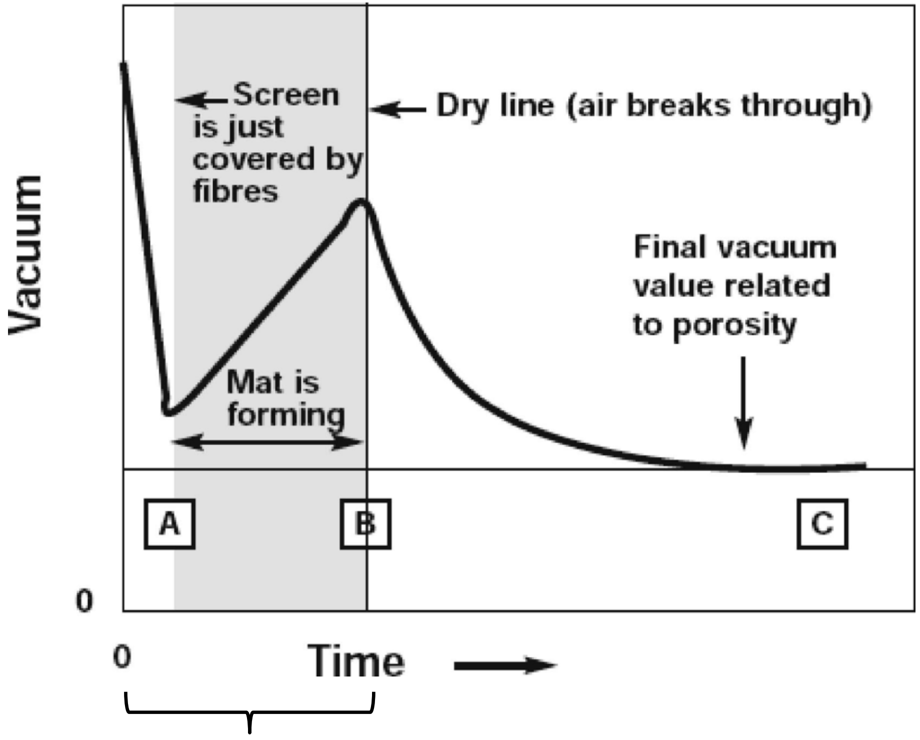




Dewatering (and web consolidation / flocculation)

Dewatering with Dynamic Drainage Analyser (DDA)





A = Time needed for free drainage of the water
B = Time needed to compact the sheet
C = f(Porosity of the sheet)
➔ 1 curve and 3 parameters per test

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Dewatering (and web consolidation / flocculation)

Xamk-RISE collaboration: Comparison on effect of MFC qualities on paper strength and dewatering

- MFC retained to similar degrees
- Different systems for drainage aid are compared at similar "chemical loadings" on the fibres (similar level of Z-potential)

”Pre-flocculation” of MFC before dewatering aid

Pulp + MFC -> CPAM -> Starch -> Microparticles

MFC typ	MFC %	CPAM kg/t	Starch kg/t	Microp. kg/t	Z-pot. mV	Drainage time sec.	End vacuum mBar
Only Pulp	0	0	0	0	-39.4	4.2	121
Xamk	3	0	0	0	-39.8	5.1	120
Xamk	3	1	4	0.4	-5.2	4.2	118
Xamk	5	0	0	0	-42.2	8.3	163
Xamk	5	1.3	4	0.2	-6.1	5.3	132
Xamk	5	1.3	6	0.6	-2.7	4.6	125
Industrial	3	0	0	0	-40.4	5.0	141
Industrial	3	0.9	2	0.2	-5.2	4.5	120
Industrial	3	0.9	4	0.8	-2.8	4.0	114
Industrial	5	0	0	0	-40.5	7.7	155
Industrial	5	1	4	0.6	-4.6	4.9	126

”Co-flocculation” of MFC with dewatering aid

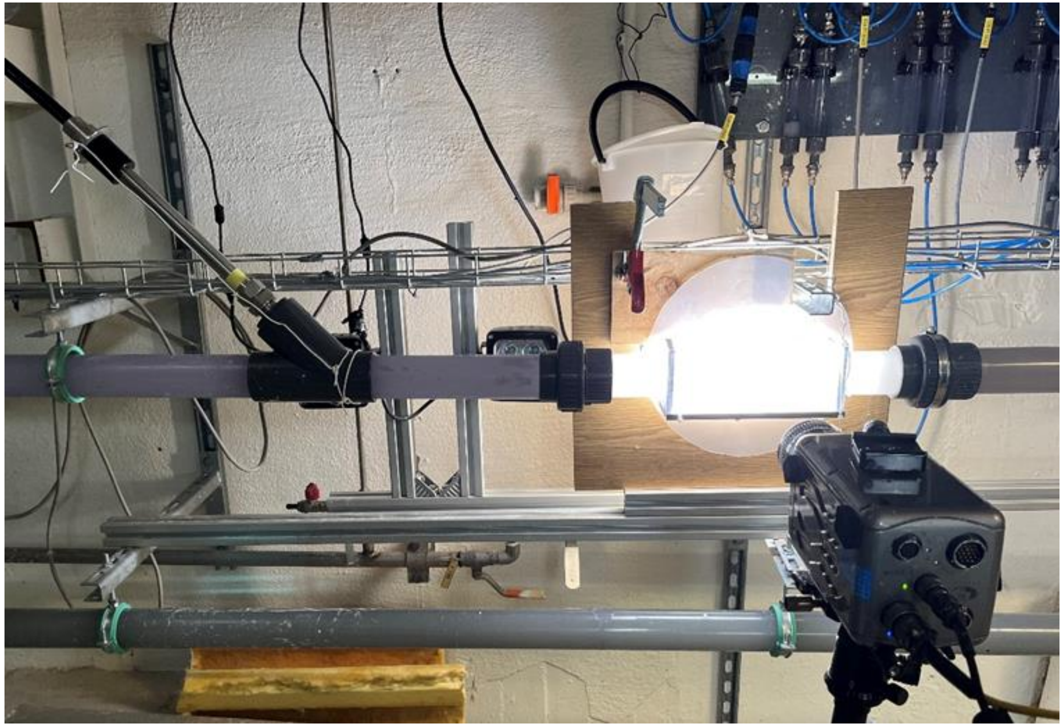
Pulp + MFC -> Starch + Hercobond

MFC type	MFC %	Starch kg/t	Hercobond kg/t	Z-pot. mV	Drainage time sec.	End vacuum mBar
Only pulp	0	0	0	-39.4	4.2	121
Xamk	3	0	0	-39.8	5.1	120
Xamk	3	5	0.5	-7.4	3.4	112
Xamk	5	0	0	-42.2	8.3	163
Xamk	5	7	0.5	-5.8	4.3	124
Industrial	3	0	0	-40.4	5.0	141
Industrial	3	6	0.25	-5.6	3.4	109
Industrial	5	0	0	-40.5	7.7	155
Industrial	5	5	0.5	-4.9	4.4	120

Impact of hydrodynamic shear and turbulence on flocculation

Pilot scale flow loop

- Designed for relevant condition (Kolmogorov coef. etc)
  - Pipe inner diameter of 5cm in combination with flow rates (0.1 -1 m^3/min)
  - Emulates approach flow and headbox conditions
- Headbox consistency, multiple dosage points (adjustable contact times)
- Characterise flocs in the suspension at two length scales using FBRM (1-1000 μm) and High-speed imaging (0.05-50 mm)



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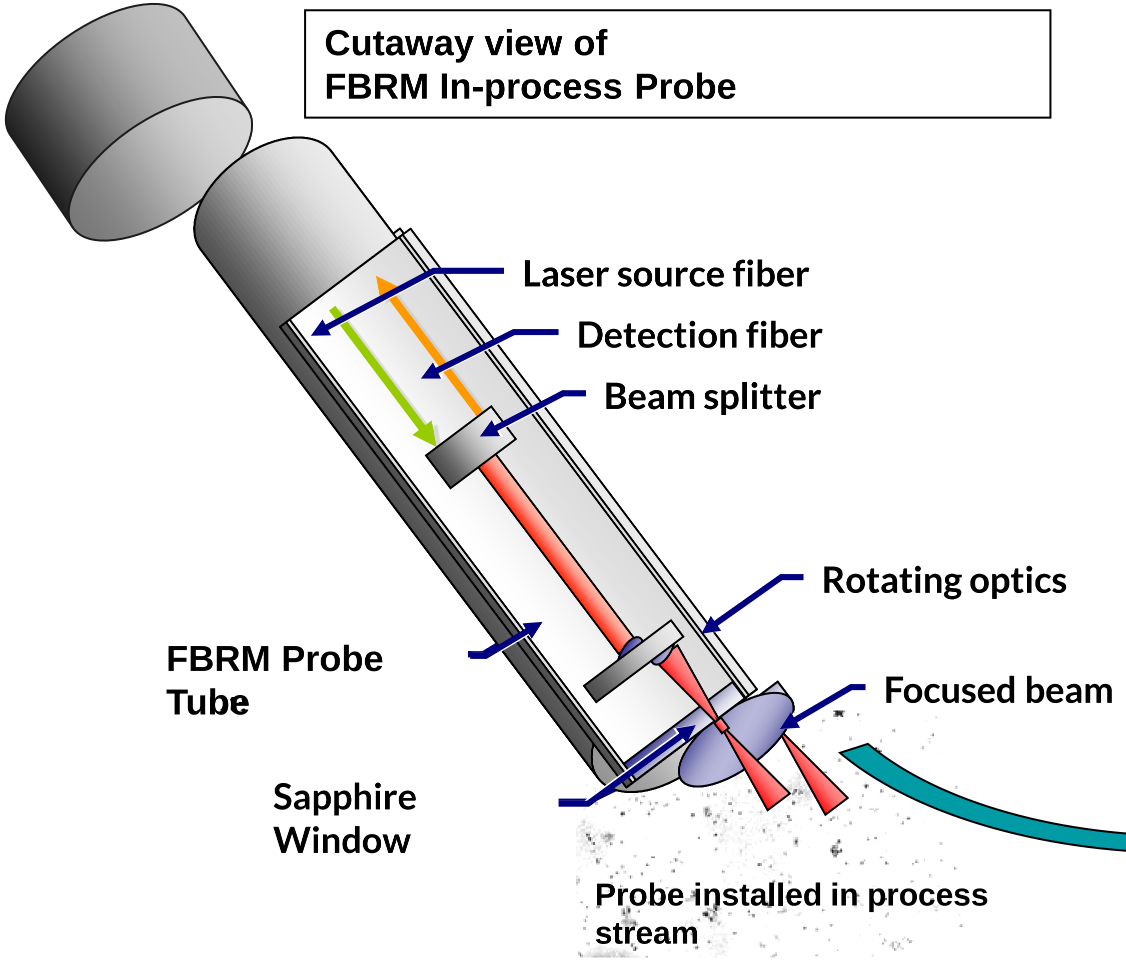
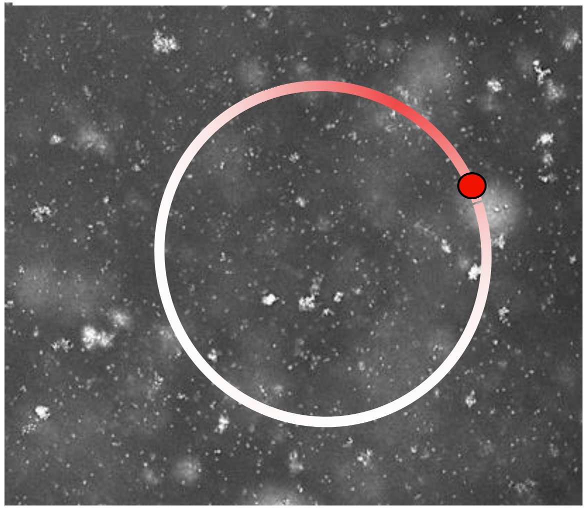
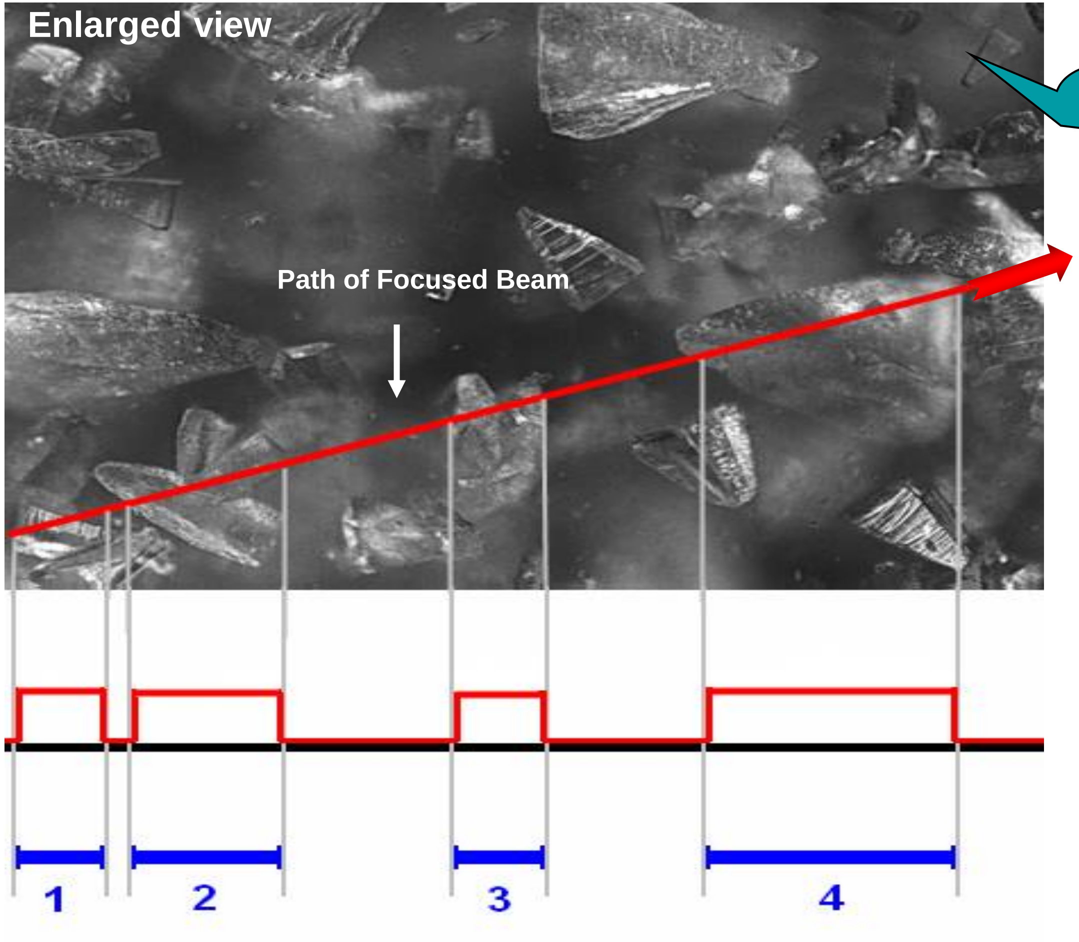
How does FBRM work?



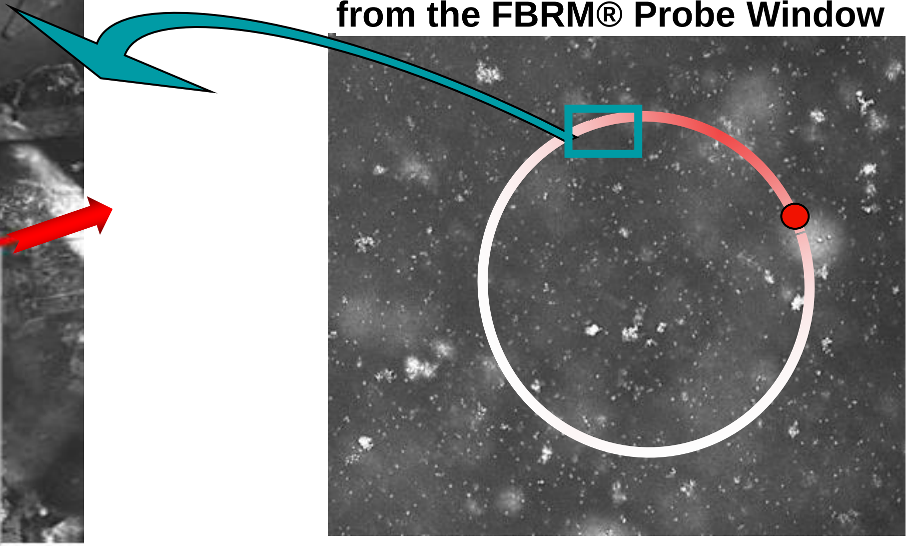
PVM® image illustrating the view from the FBRM® Probe Window



What is FBRM® Technology?



PVM® image illustrating the view from the FBRM® Probe Window



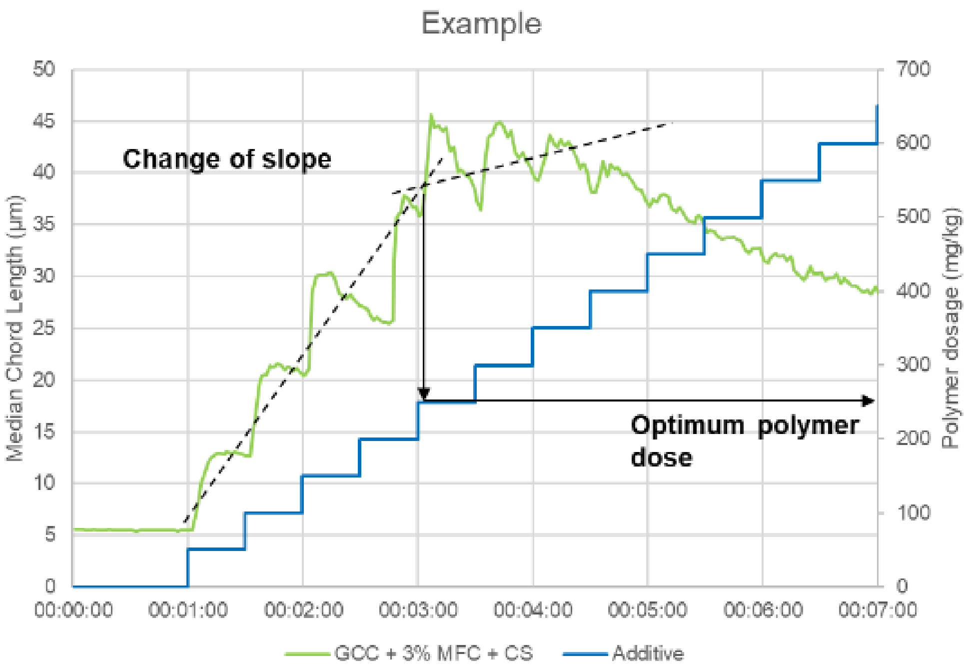
Probe detects pulses of Backscattered light

And records measured Chord Lengths

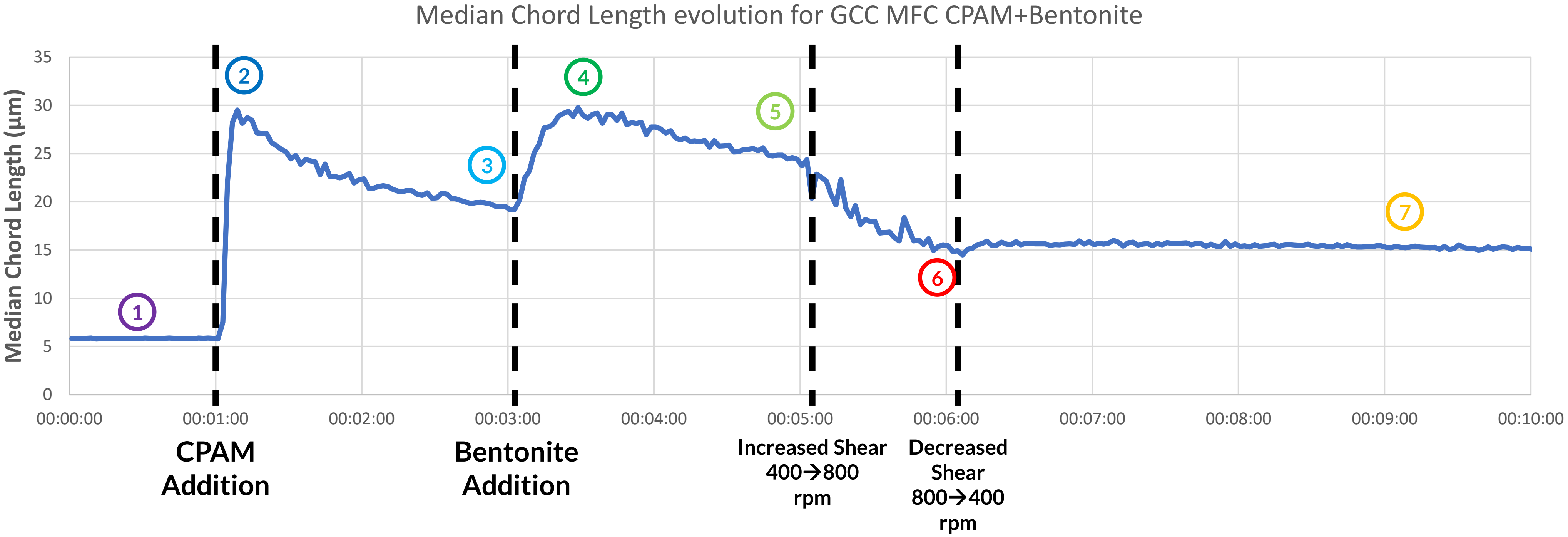
This core patented technology is called Focused Beam Reflectance Measurement [FBRM®]

Method: Dosage optimization

- The polymer is added on the GCC or GCC+MFC suspension.
- The evolution of the particle size (as Median of the chord length distribution) can be followed.
- An optimum dosage can easily be identified



Method: Floc resistance - Example



Sample	1	2	3	4	5	6	7
Median Chord Length (µm)	5,8	29,5	19,8	29,4	24,8	15,0	15,4
Size variation (µm)	0	+23,7	-9,7	+9,6	-4,6	-9,8	+0,4

Shear flow study: Xamk-RISE

”Pre-flocculation” of MFC before dewatering aid

Pulp + MFC -> CPAM -> Starch -> Microparticles

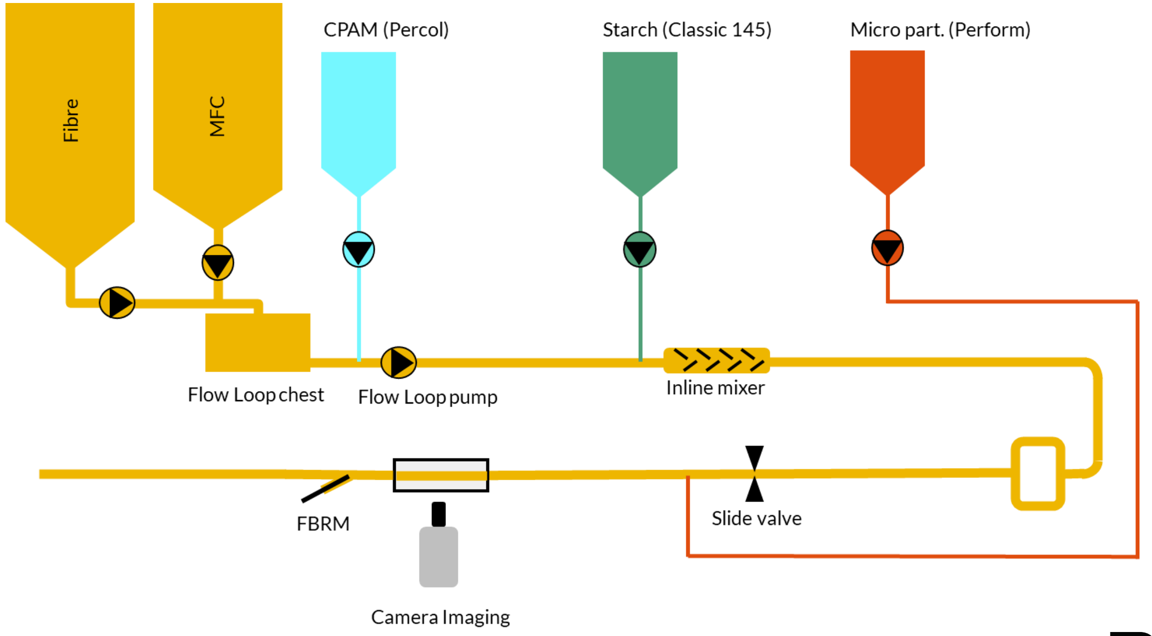
Example on trial points

Optimized for dewatering
Set pre-flocculation of MFC

Optimized for dewatering,
Low degree of pre-flocculated MFC

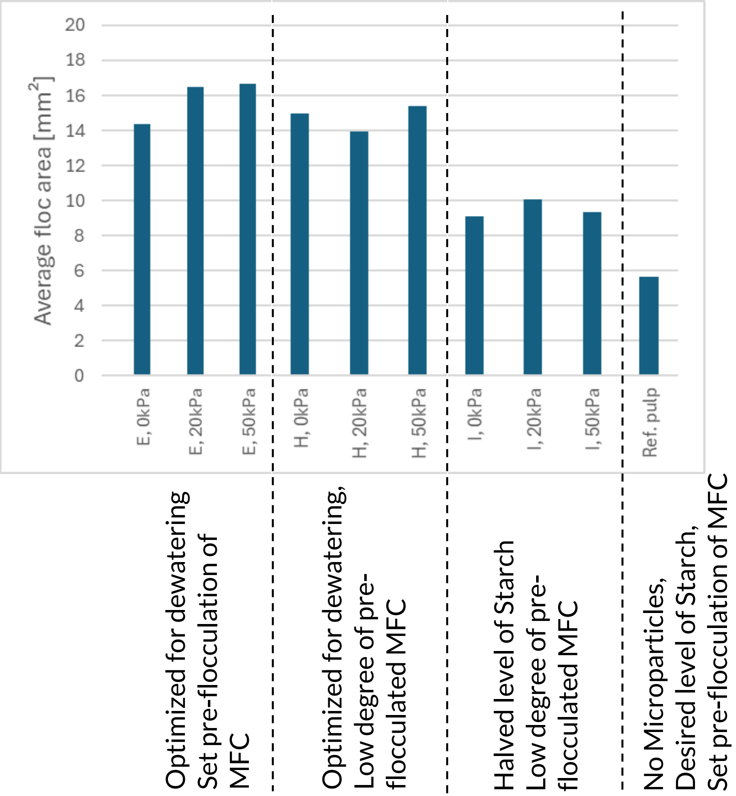
Halved level of Starch
Low degree of pre-flocculated MFC

No Microparticles, Desired level of Starch,
Set pre-flocculation of MFC

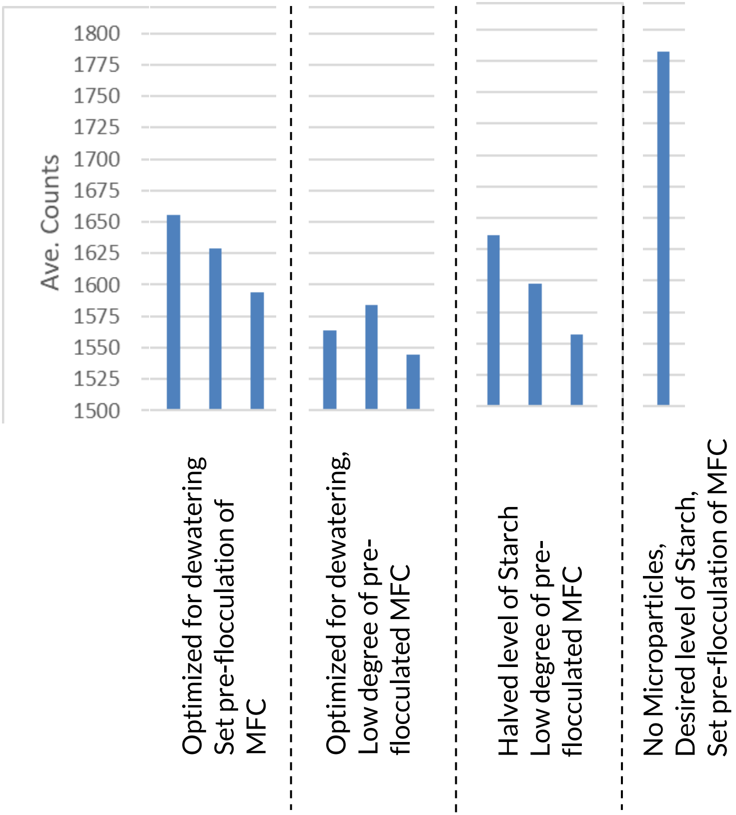


Resultat examples from flow loop

High-speed imaging [mm scale]



FBRM [μm scale]



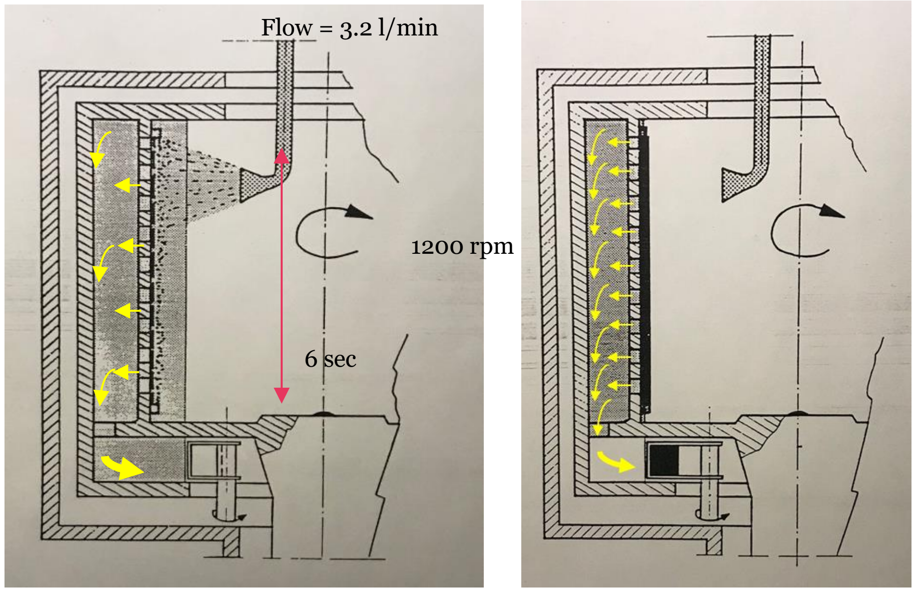
The dewatering system (starch and microparticles accounts for fibre flocculation (mm scale)

? Possibly: Microparticles interact with dispersed fines/MFC, further enhanced with turbulent mixing?

Dynamic sheet former

Designed to be more paper machine like (compared to conventional sheet former)

- Higher consistencies
- Sequential stock preparation at stirring
- Applies shear forces on the suspension during build-up of the sheet
- Jet-wire speed difference induces sheet anisotropies (MD/CD ratios)
- Multiple plies from different stock



Sketch from C. Pierre First workshop in Munich PTS (1995)

Example: Strength improvement with MFC

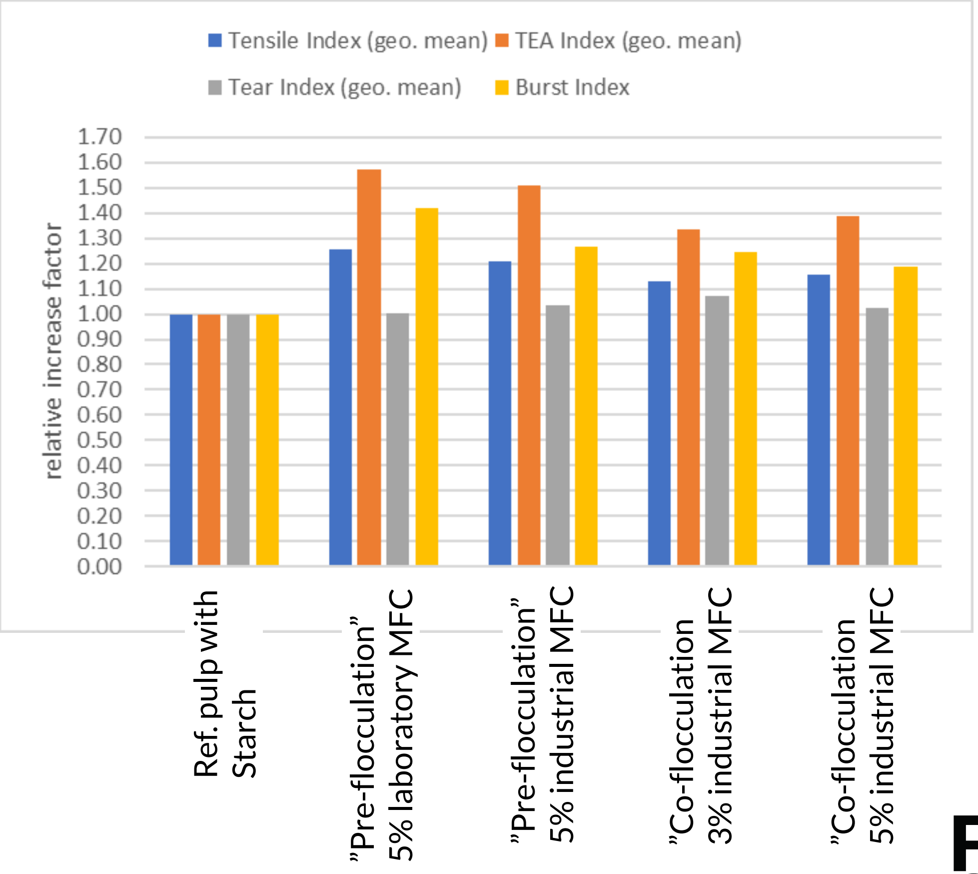
Xamk-RISE collaboration

”Pre-flocculation” of MFC before dewatering aid

Pulp + MFC -> CPAM -> Starch -> Microparticles

”Co-flocculation” of MFC with dewatering aid

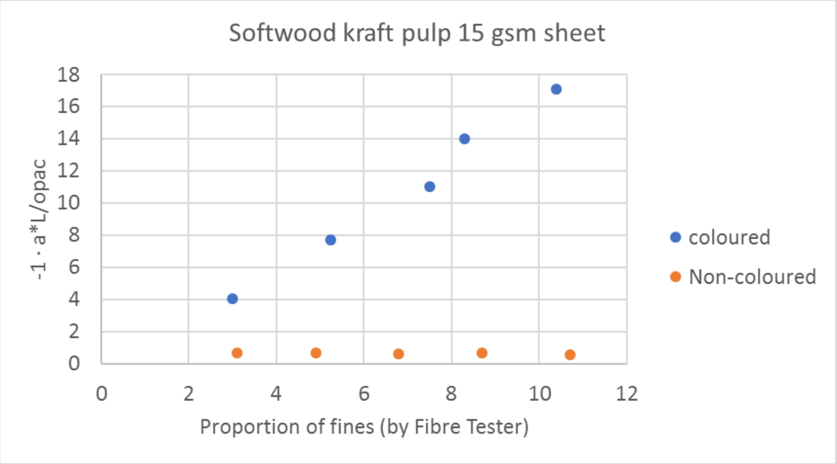
Pulp + MFC -> Starch + Hercobond

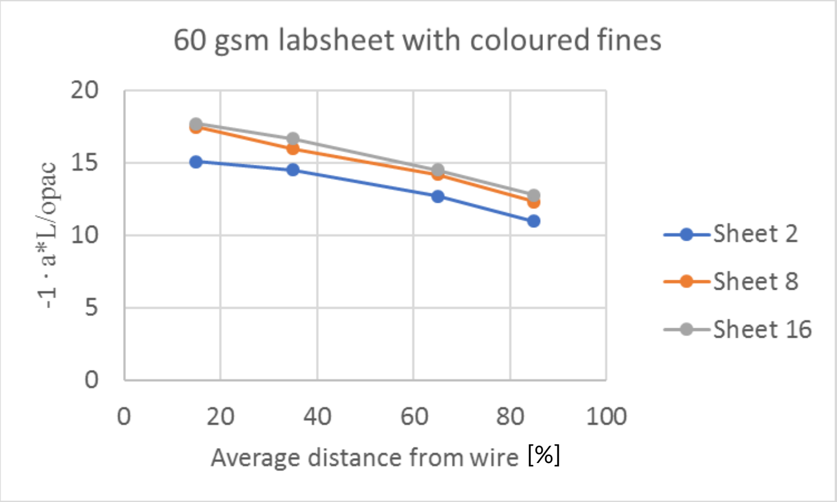


Distribution of MFC in thickness direction

DSSP method

- Dyed Split SpectroPhotometric method
- Fines or MFC is dyed with Pergasol Blue and mix with the pulp.
- Produced sheets are split into layers of 10-15 gsm with help of heat set laminations pouches
- The splits are characterised spectrophotometrically to obtain the opacity and colour shades
- Calibration using corresponding pulp with non-dyed fines/MFC results in weight proportion of MFC in each plie of the split sheet





Hansen P. H. F., Innventia Report NO 889 (2017).

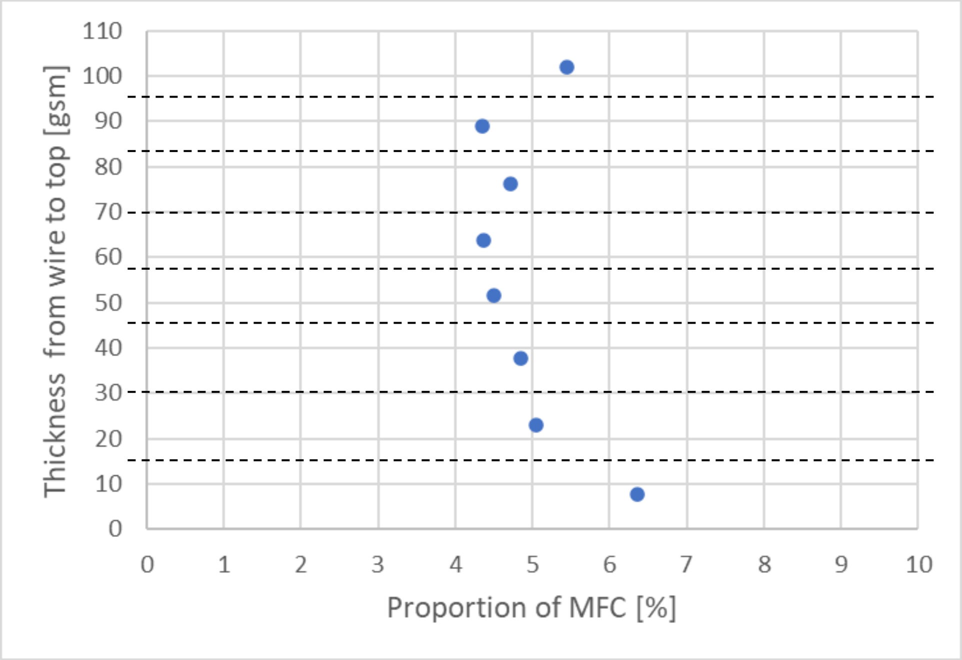
Example: MFC distribution in thickness direction, dynamic sheet

Xamk-RISE collaboration

- ”Pre-flocculation” of MFC

  Pulp + MFC -> CPAM -> Starch -> Microparticles

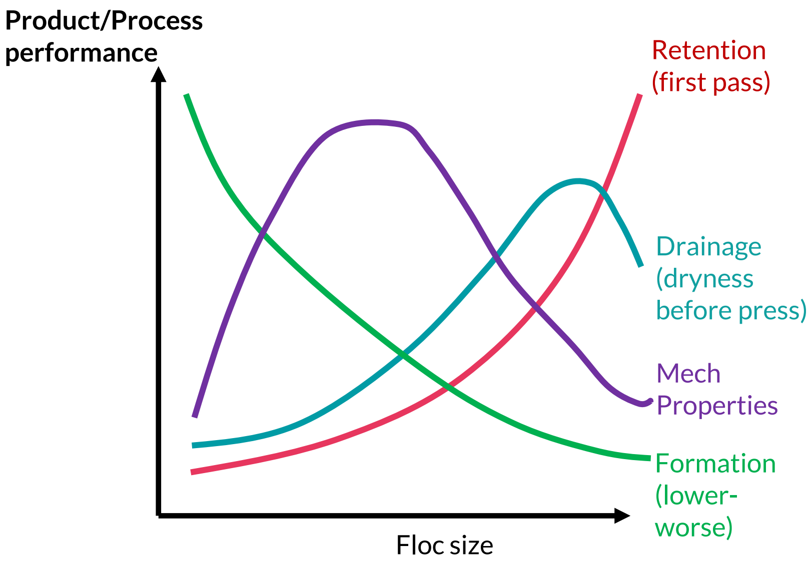
- A total of 5% industrial MFC in the pulp



In short, the approach utilised by RISE

Good utilisation of MFC requires

- Management of available charge (Z-potential, Cationic demand)
- Controlled sheet design
  - Balance retention and dewatering (DDA)
  - Flock size distribution is a key (FBRM is useful when fillers are present)
  - Aim for even distribution of MFC in thickness direction. (Lab. & pilot sheet production + DSSP)
- Boundaries/conditions in the papermaking process and process water quality set the scope for MFC utilisation
  - Behaviours under hydrodynamic shear need to be understood (Dynamic sheet forming, Flow loop studies)



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