STRUCTURAL INFLUENCES ON REVERSIBLE AND IRREVERSIBLE CURL

ВЛИЯНИЕ СТРУКТУРЫ НА ОБРАТИМУЮ И НЕОБРАТИМУЮ СКРУЧИВАЕМОСТЬ БУМАГИ

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Overview

- Motivation
- Introduction
- Results
  - Fibre orientation in z-direction
  - Dried-in strains
- Conclusion

Motivation

- Better understanding of curl mechanisms

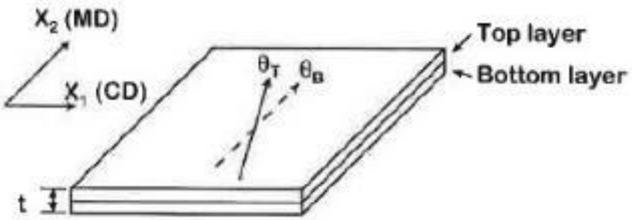
- Influence of wire shaking on office paper
  - in machine direction
    - via ultrasonic measurement (TSO)
  - in z-direction/thickness direction
    - via laminate splitting

  - Investigation on dried-in strains
    - Climate cycles to release “frozen” tensions

Source: Uesaka

Introduction (1): Curl mechanisms

- STRUCTURAL CURL
  - Two sidedness (FO, Filler, etc.)
  - Structure of paper

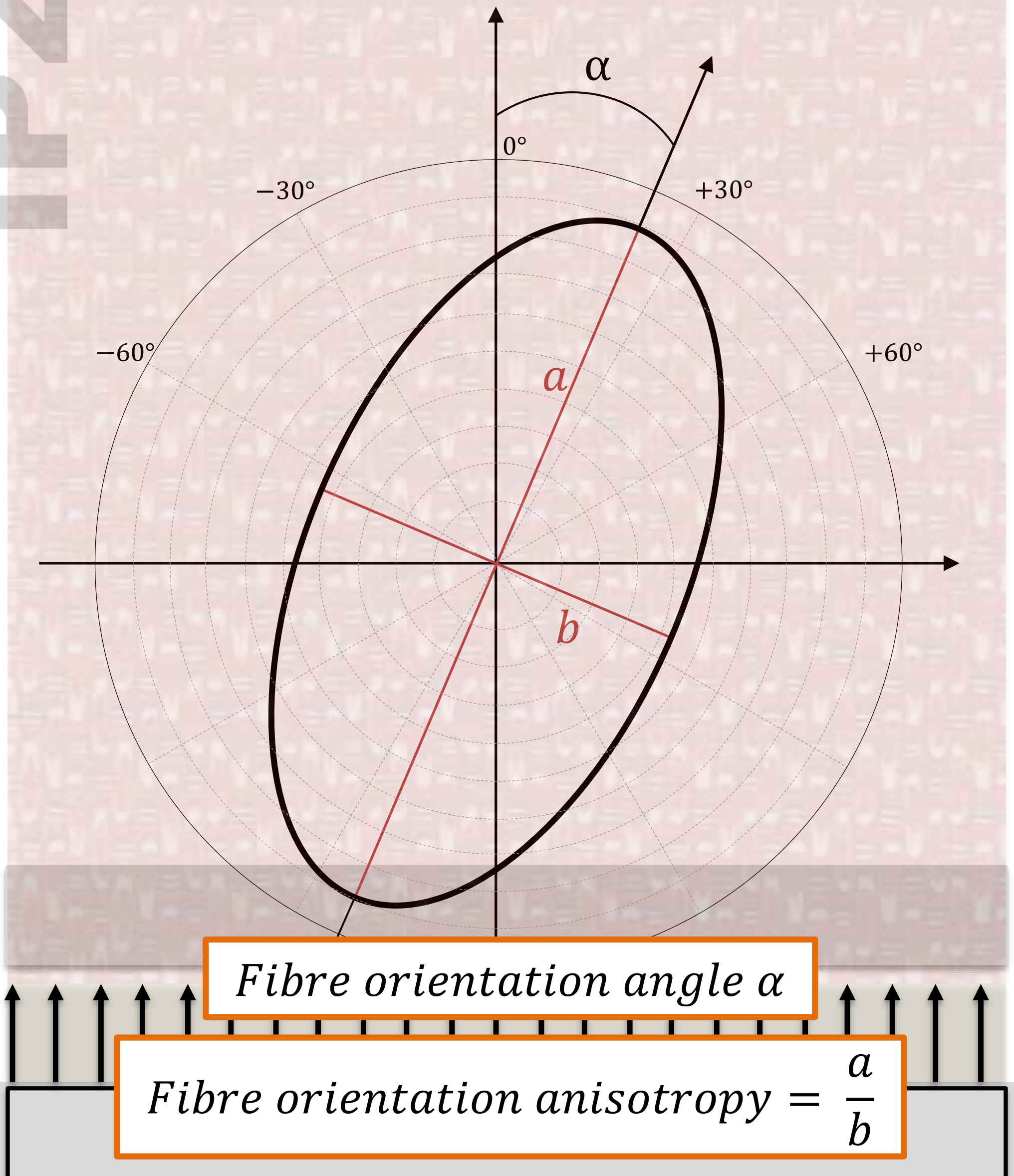


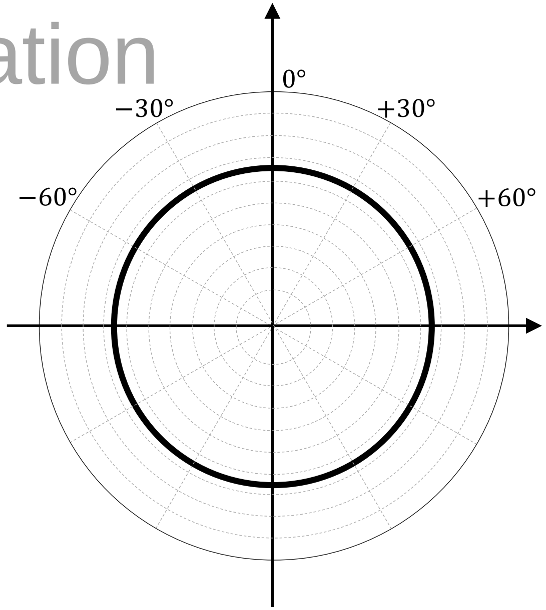
- VISCOELASTIC CURL
  - Copying: curl toward anti-image side

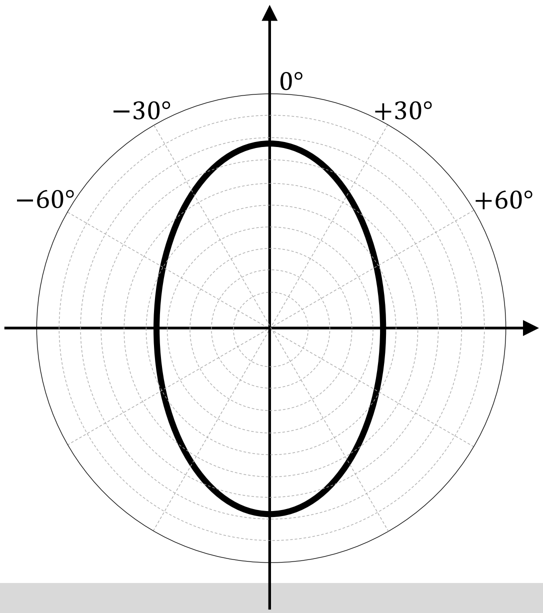
- ROLL-SET CURL

- IRREVERSIBLE CURL
  - Dried-in strains

Introduction (2): Fibre orientation



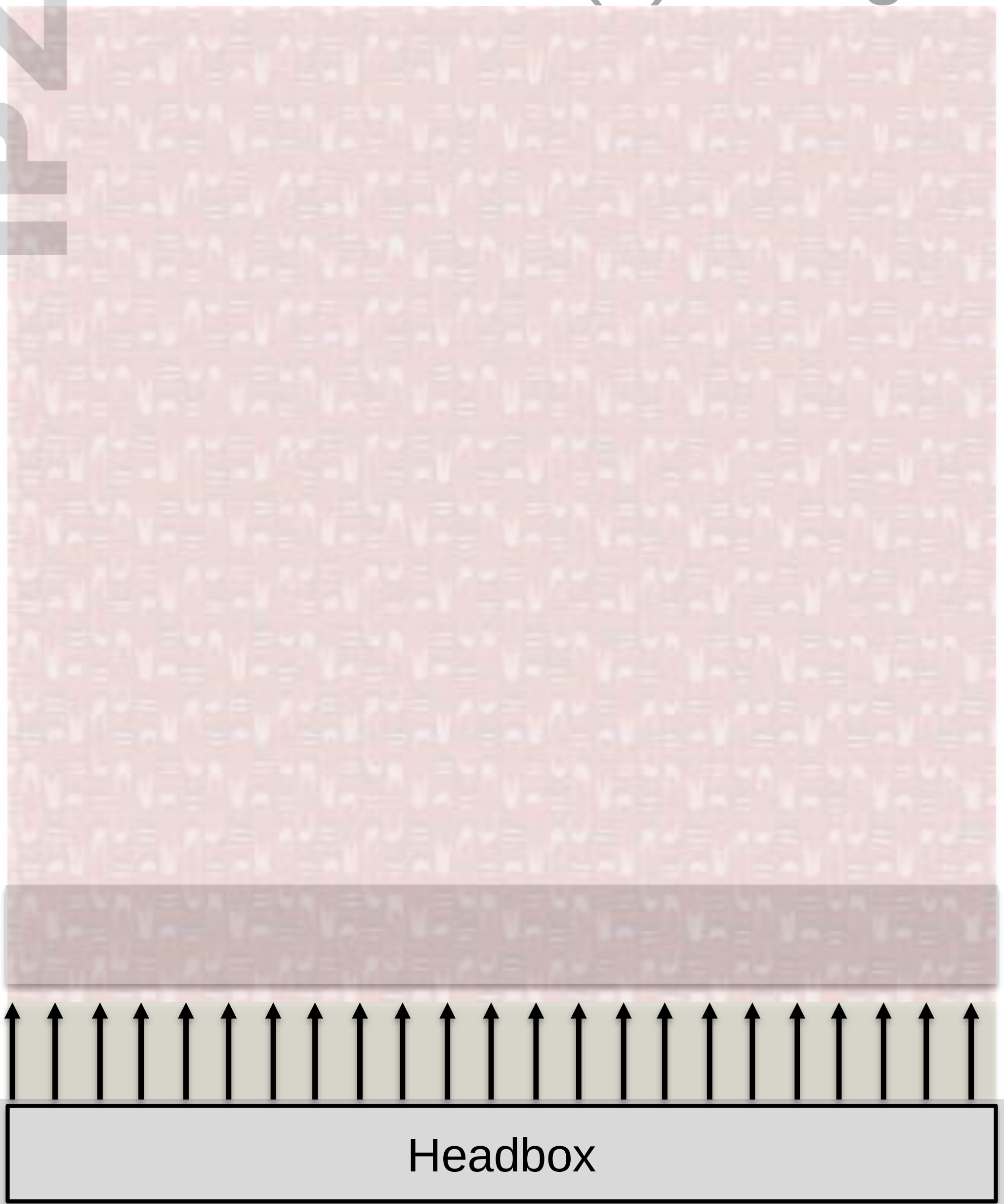


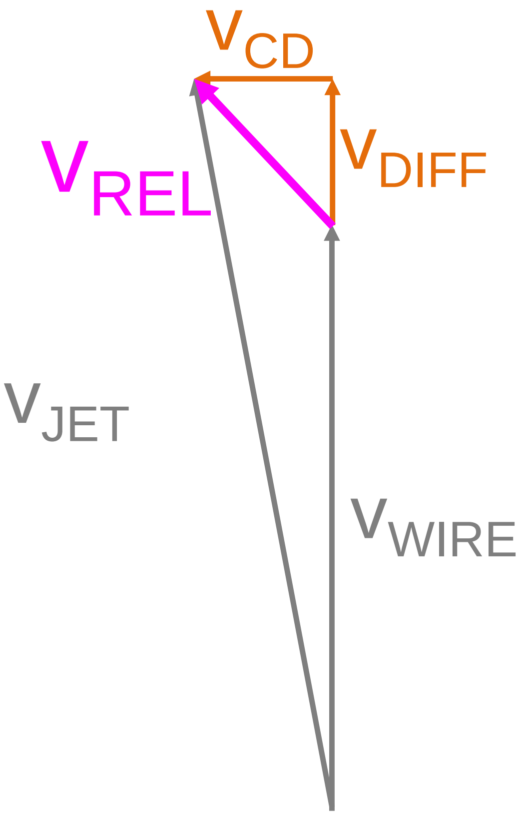


Fibre orientation angle α

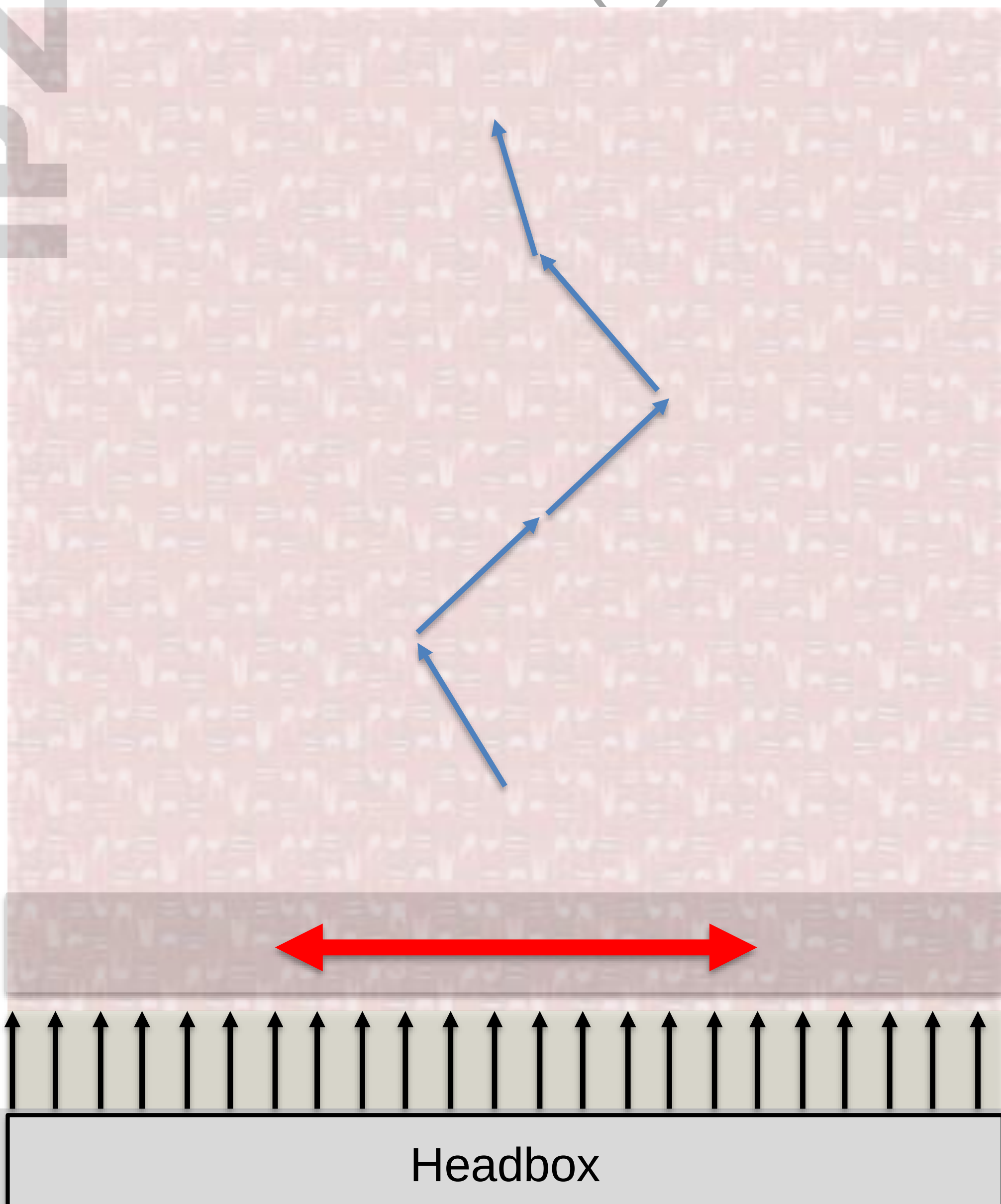
$$Fibre\ orientation\ anisotropy = \frac{a}{b}$$

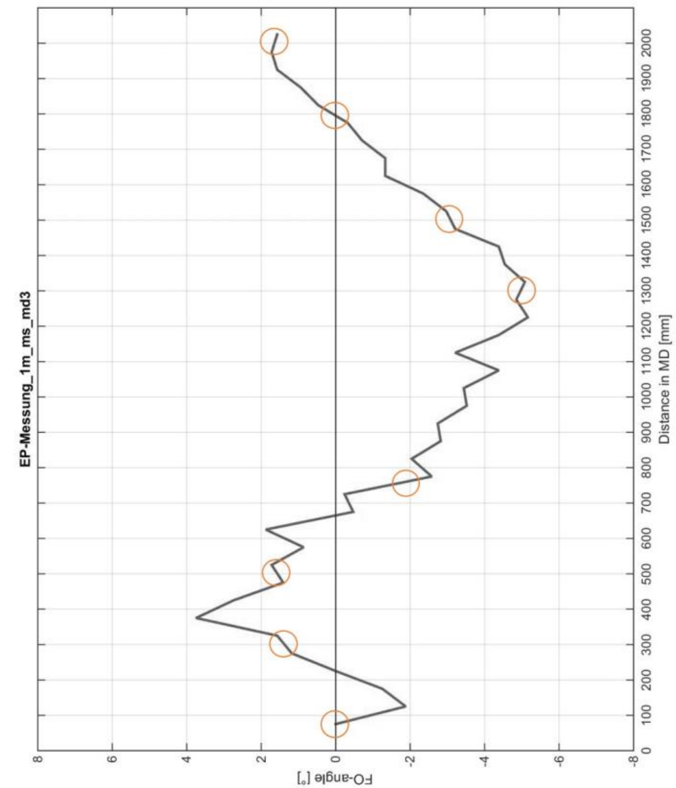
Introduction (3): Drag

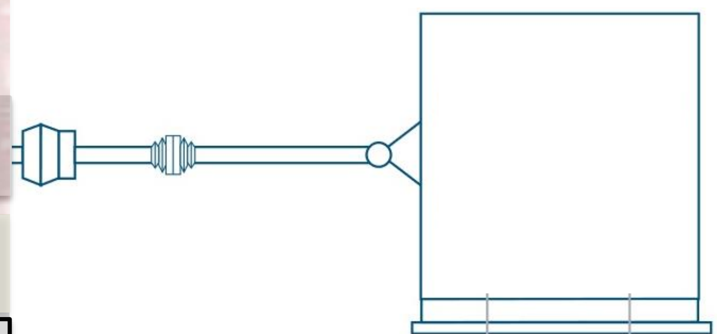




Introduction (4): Wire shake



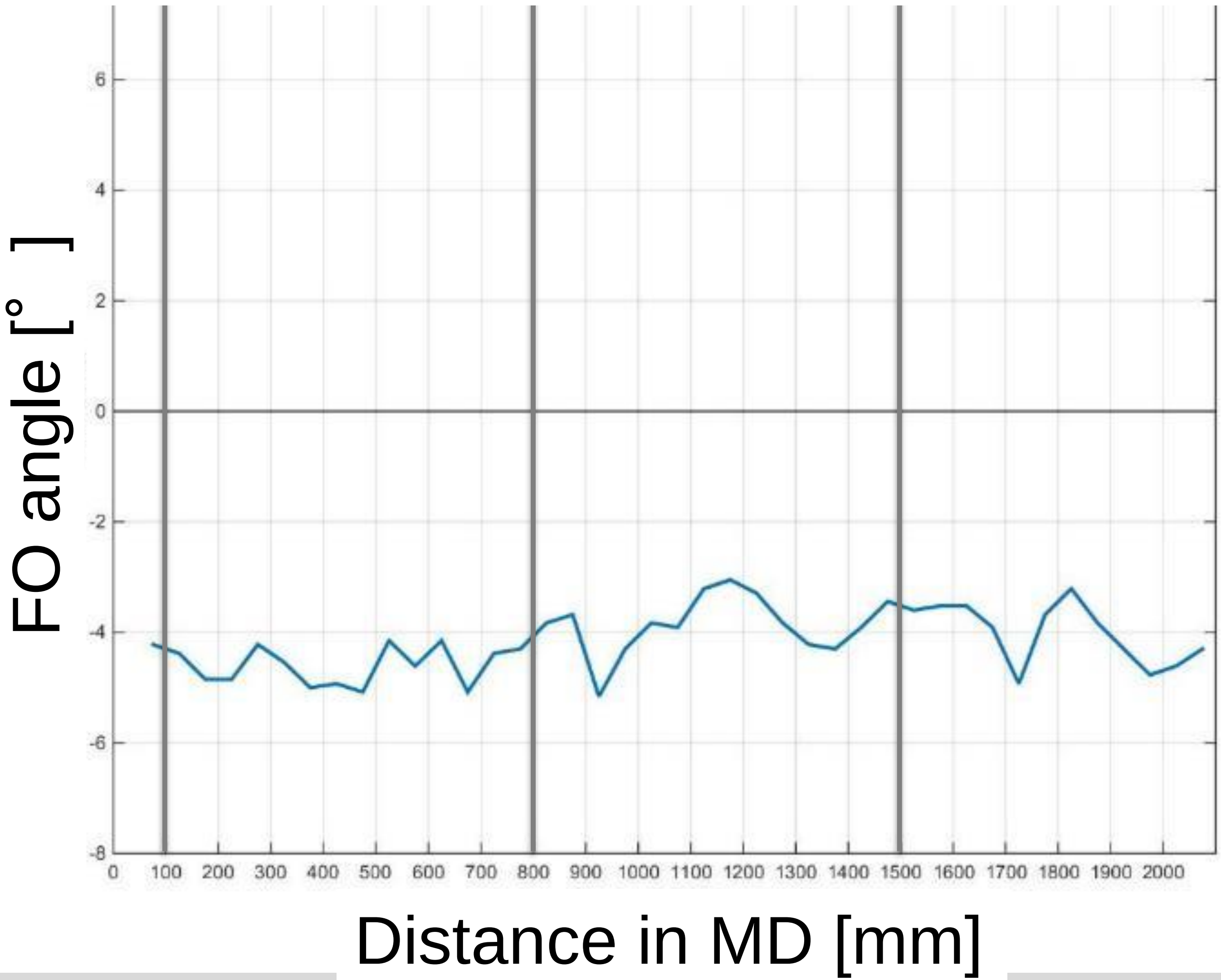




Results

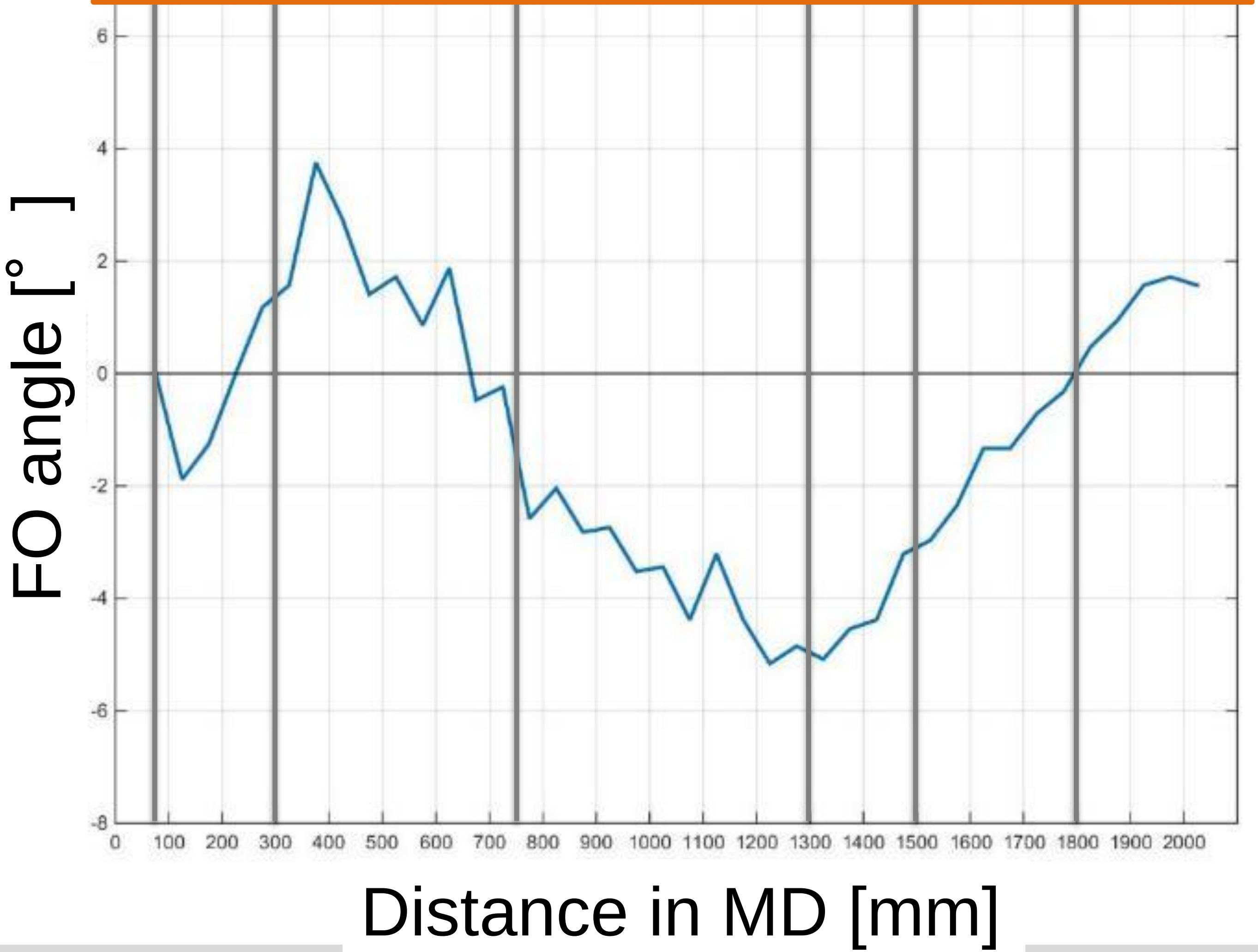
- Effect of wire shake in machine direction
  - TSO measurement of 2m stripes
- Structure in thickness direction
  - Laminat splitting
    - Dying, splitting and scanning of 38x90mm samples
- Visualization of dried-in strains (irreversible curl)
  - Climate cycles (RH 30%,50% and 90%)

No wire shake: FO Angle (TSO)

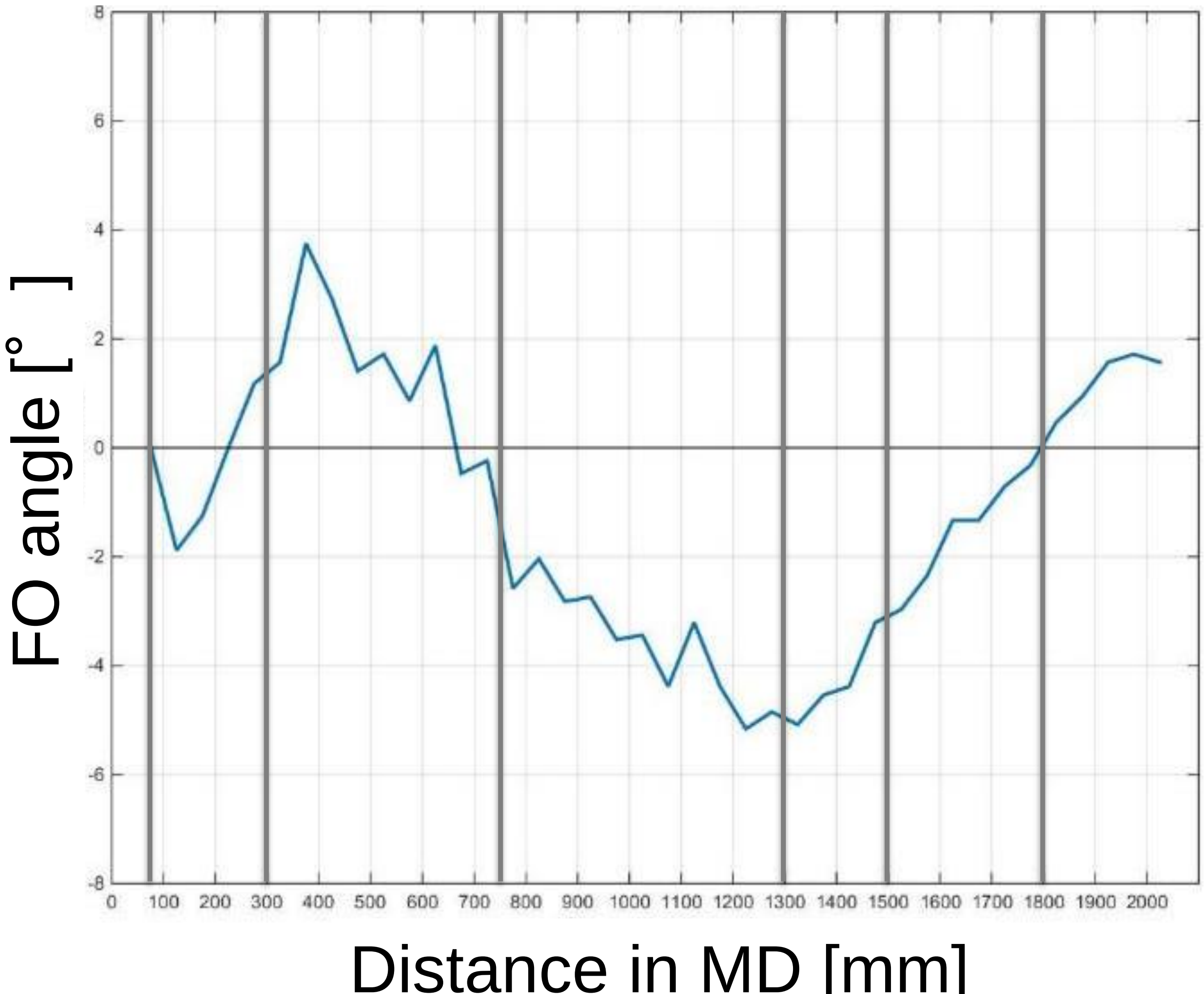


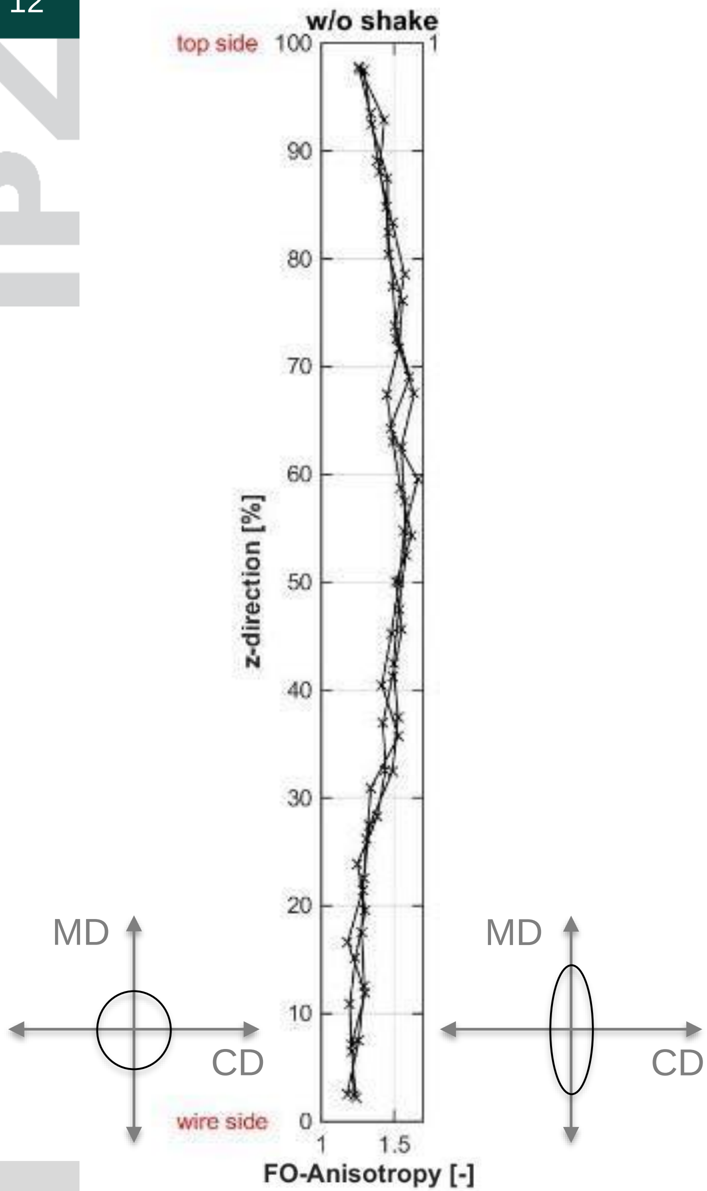
Wire shake: FO Angle (TSO)

$$T = \frac{wire\ velocity}{shaking\ frequency}\left[\frac{m/min}{1/min}\right] = \frac{600\ m/min}{400\ 1/min} = 1{,}5\ m$$

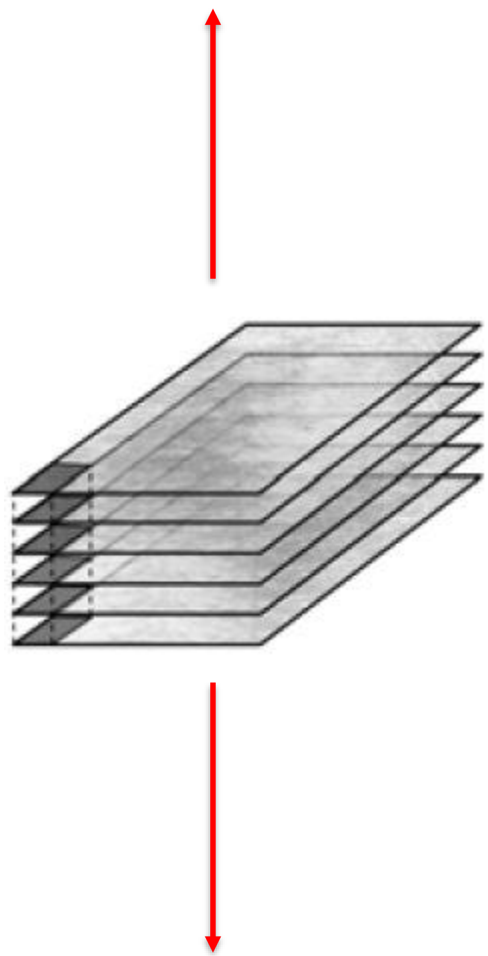


Wire shake: FO Angle (TSO)

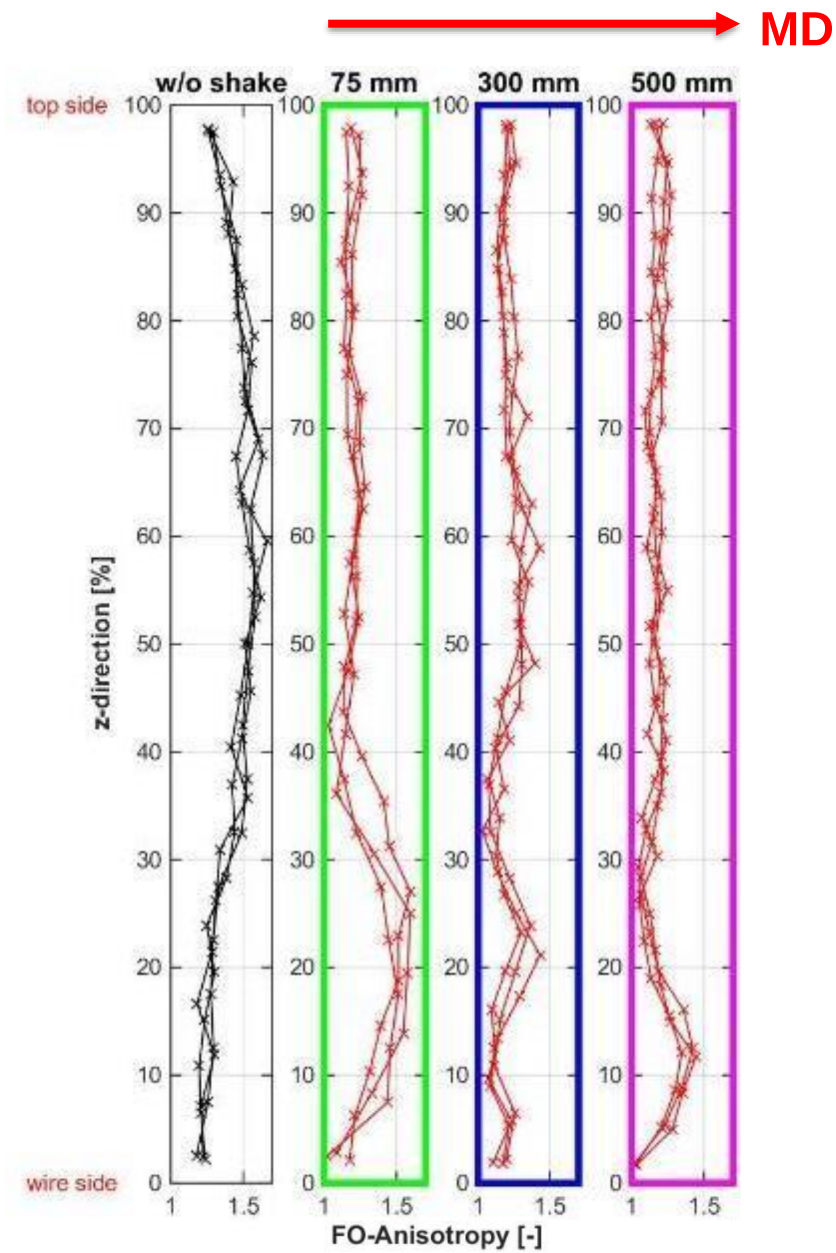


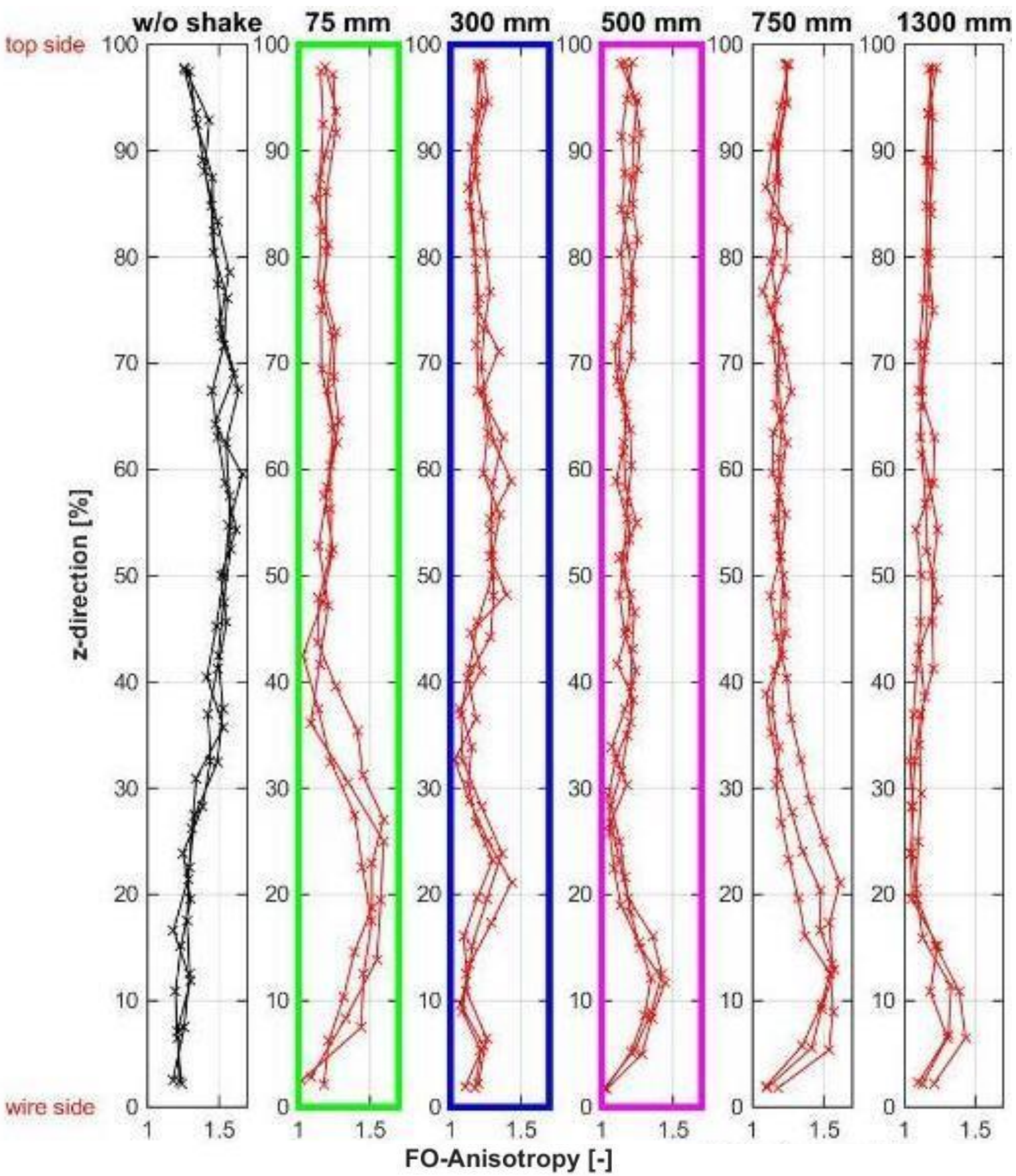


Top side

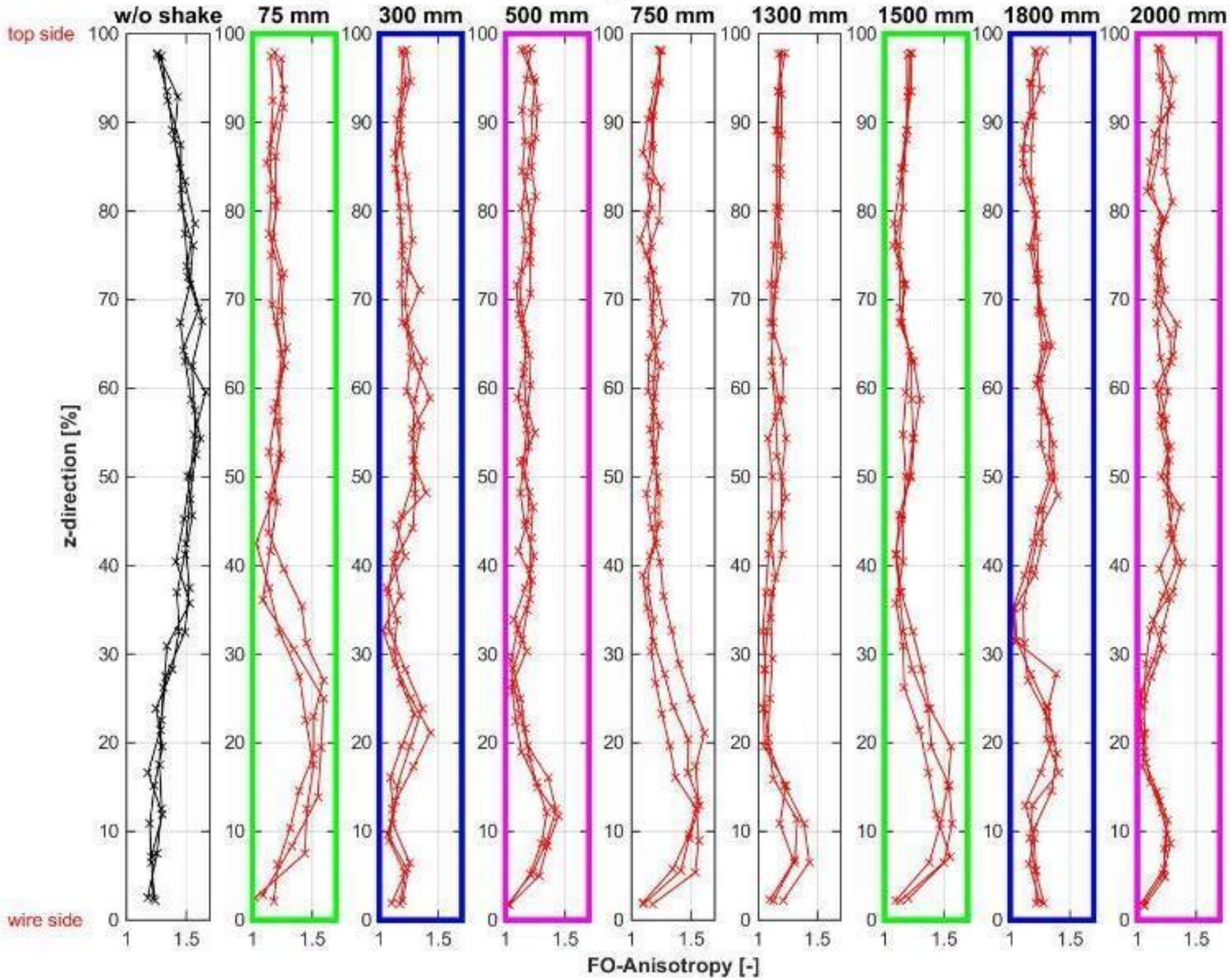


Wire side


MD
w/o shake
75 mm
300 mm
500 mm
top side
wire side
z-direction [%]
FO-Anisotropy [-]

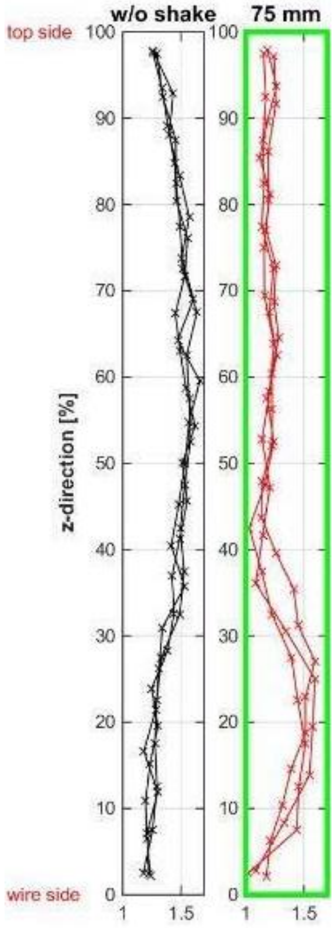

w/o shake
75 mm
300 mm
500 mm
750 mm
1300 mm
top side
wire side
z-direction [%]
FO-Anisotropy [-]
100
90
80
70
60
50
40
30
20
10
0
1
1.5

Drag @ web center



Results Anisotropy

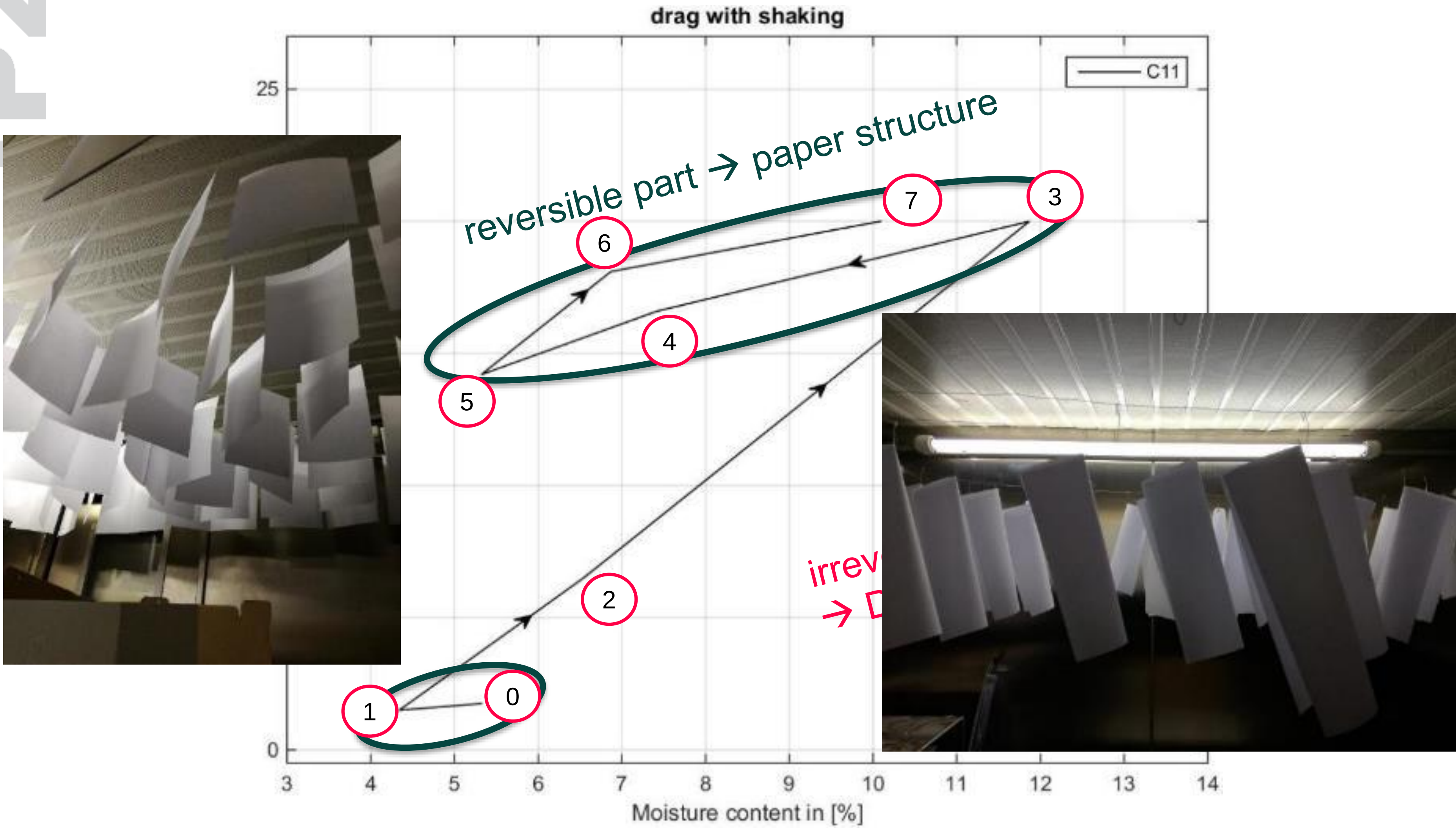
- Shake shifts Anisotropy two-sidedness
  - Smaller section with anisotropy
  - Similar look for different settings
    - 70-80% isotropic
    - Wire side shows (small) anisotropy



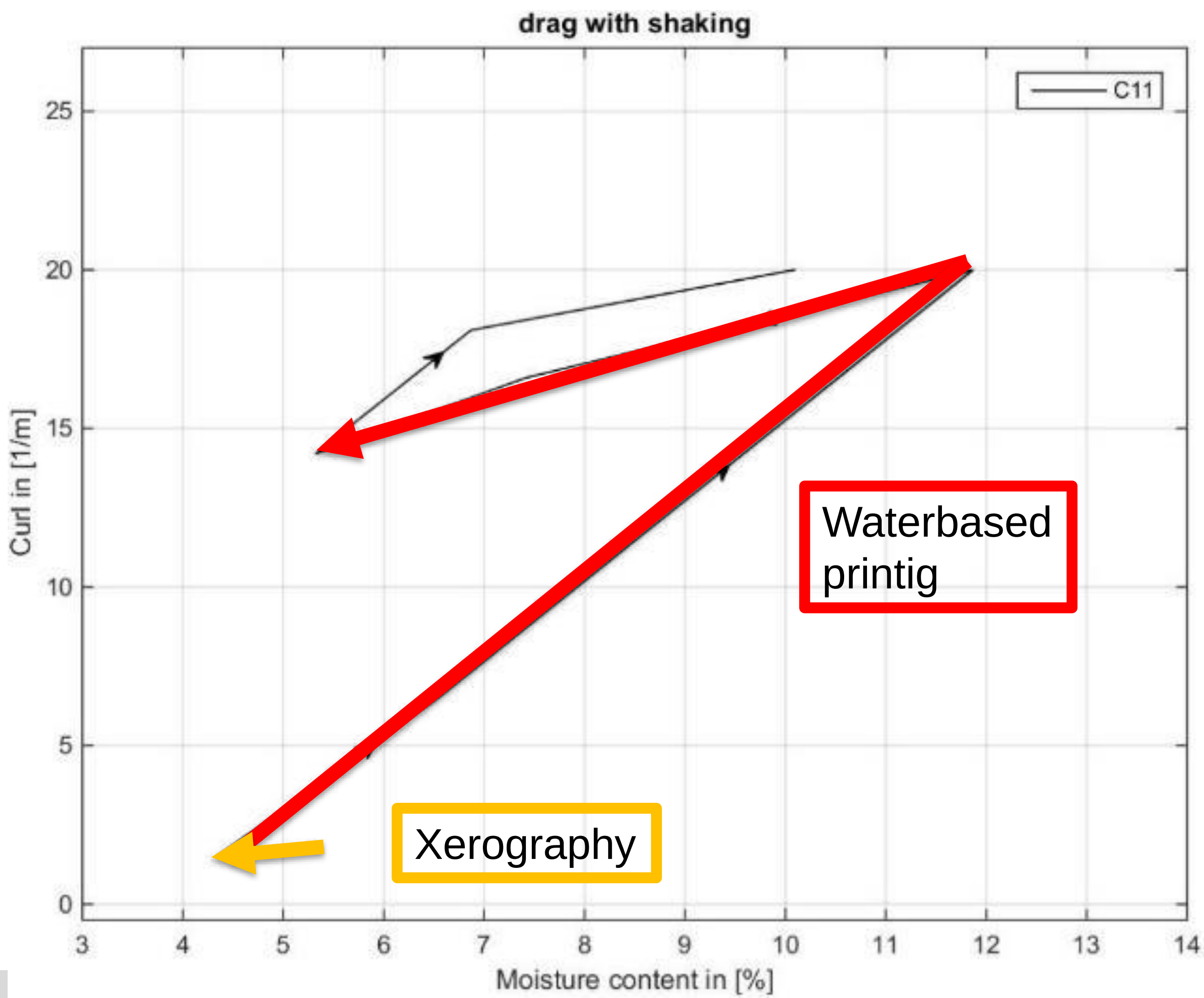
Dried-in strains (Irreversible curl)

- Different handling of both paper sides leads to tensions
- Under restrain these tensions cannot manifest
  - → “Freezing” of the tensions
- Climate cylces should show dried-in tensions

Irreversible curl (1): Measurement

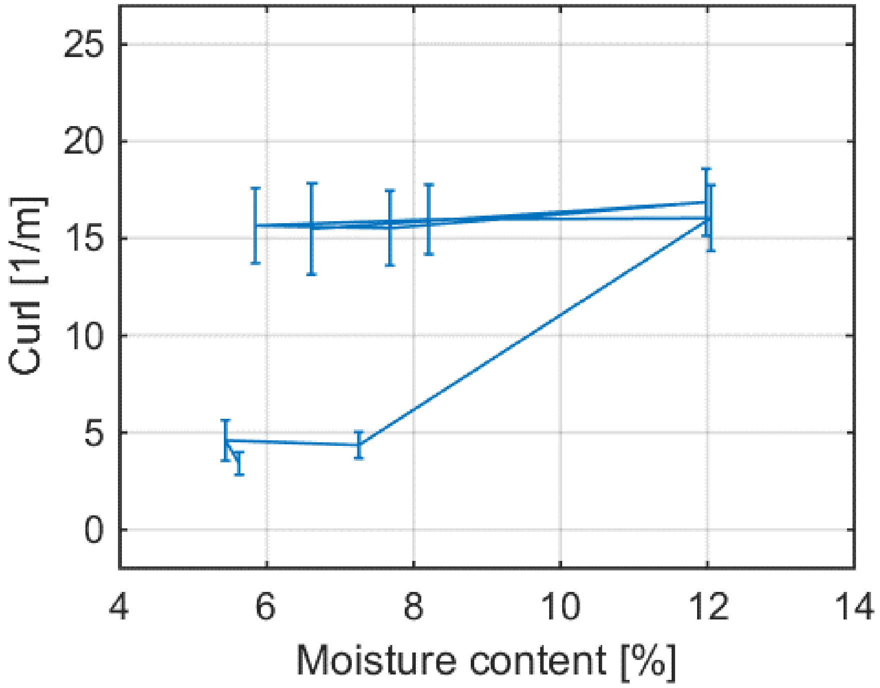


Results Dried-in strains



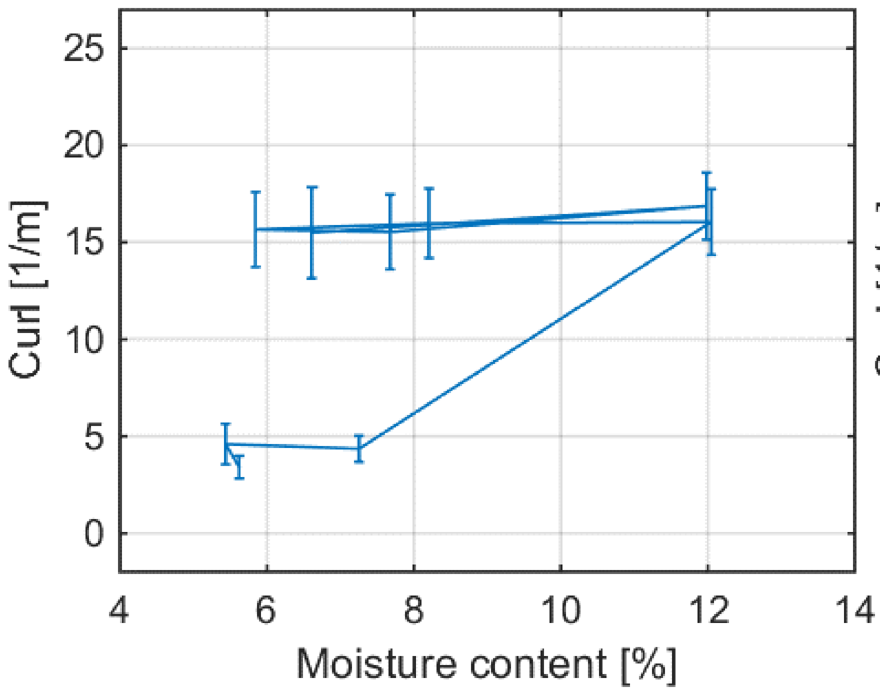
Drag @ web edge

Without shaking

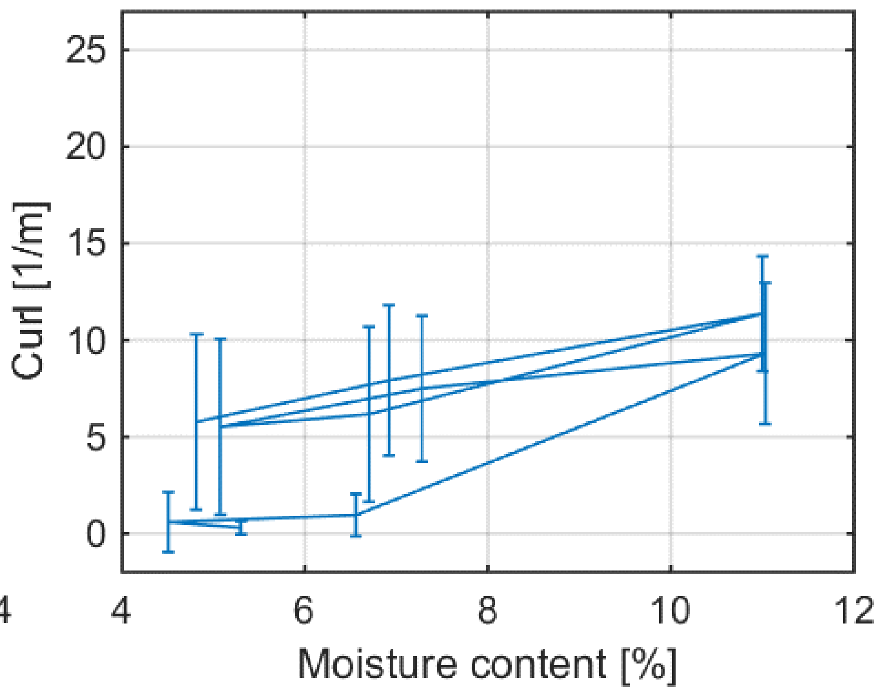


Drag @ web edge

Without shaking



With shaking



Conclusion on tested papers

- Effect of wire shaking in machine direction in form of a repeating sine
- Wire shaking smoothens anisotropy z-profiles and only lefts a small anisotropy at the bottom side of the paper
- Repeating effect of the wire shake manifests also in the z-profiles
- Dried-in strains can be made visible by climate cycles
- Wire shaking reduces irreversible curl

Thank you for your attention.