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Calibration and Optimization of a SimulationX Model for the mechanical dewatering process of pulp webs

WOST 2020

Timo Frick | 2020-06-25

Introduction
Voith in numbers

In more than **60** countries

19 500 employees

5 markets

R&D ratio

5.3 %

Family-owned since

1867

Sales

€4.2 Billion

As of: 2017/18

Paper

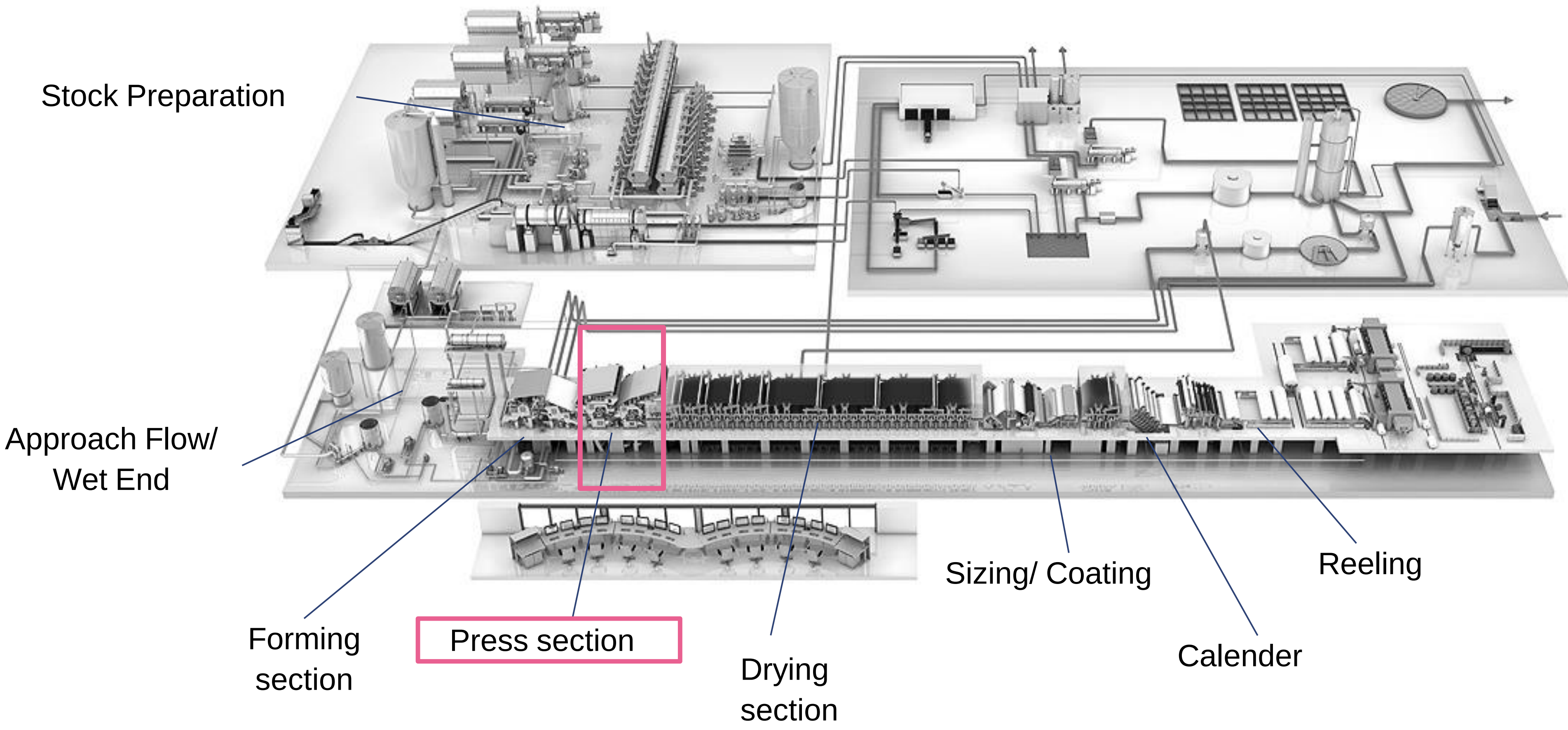
Technologies from Voith are used in all sectors of the paper industry. A large proportion of the world’s paper is produced on Voith paper machines.

WOST 2020
Agenda

1. Papermaking Process
2. Press Model
3. Compression Model Calibration
4. Optimization of Press Profile
5. Summary

Papermaking Process

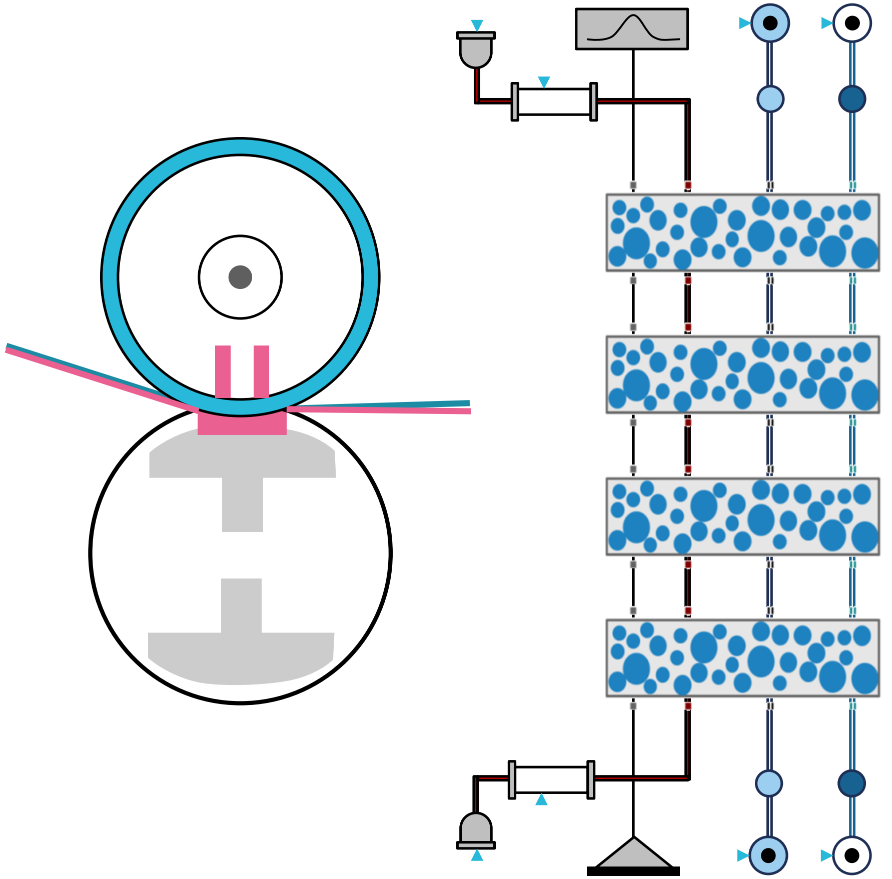
Papermaking Process
Overview



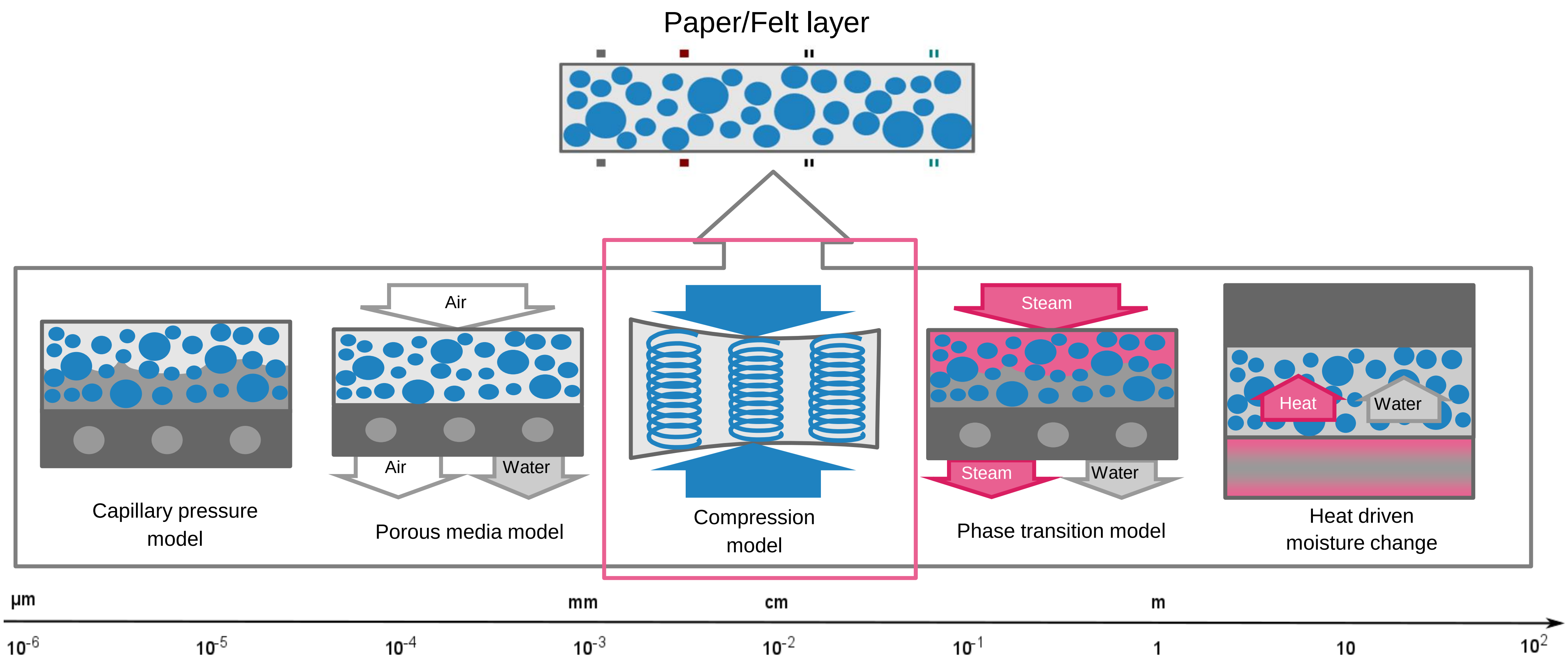
Press Model

Press Model
Introduction

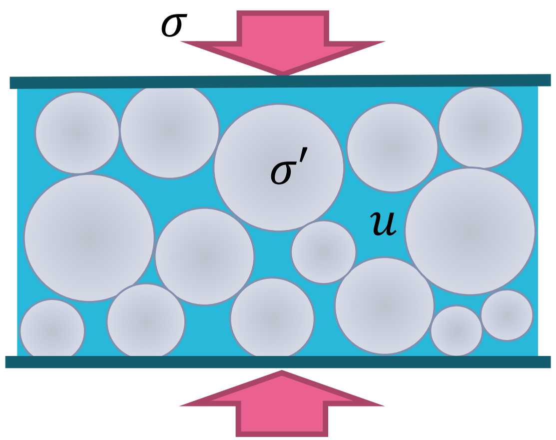
- High loads and very **short pulse times** make it nearly impossible to reproduce press nip on lab equipment
- **Complex physics** involving structural stress of porous materials, capillary pressure and multiphase flow make it hardly accessible for microscopic simulations
- **Process simulations** using effective material parameters help in understanding interplay of elastic and plastic **deformation** and **dewatering**



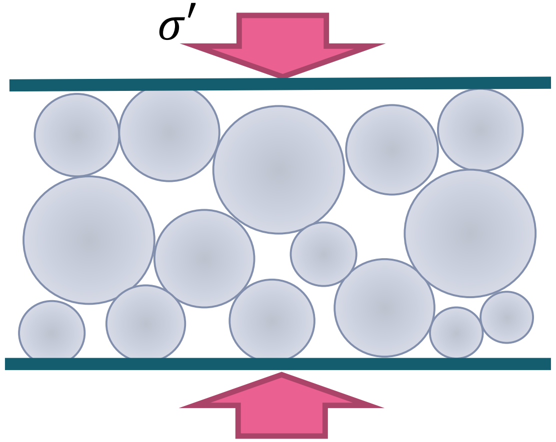
Press Model
Functional layers



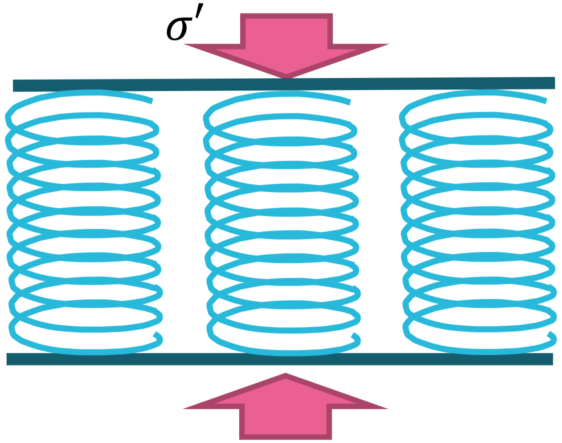
Press Model
Compression Model



Terzaghi's principle: Porous material subjected to **stress** is opposed by **fluid pressure** of pores

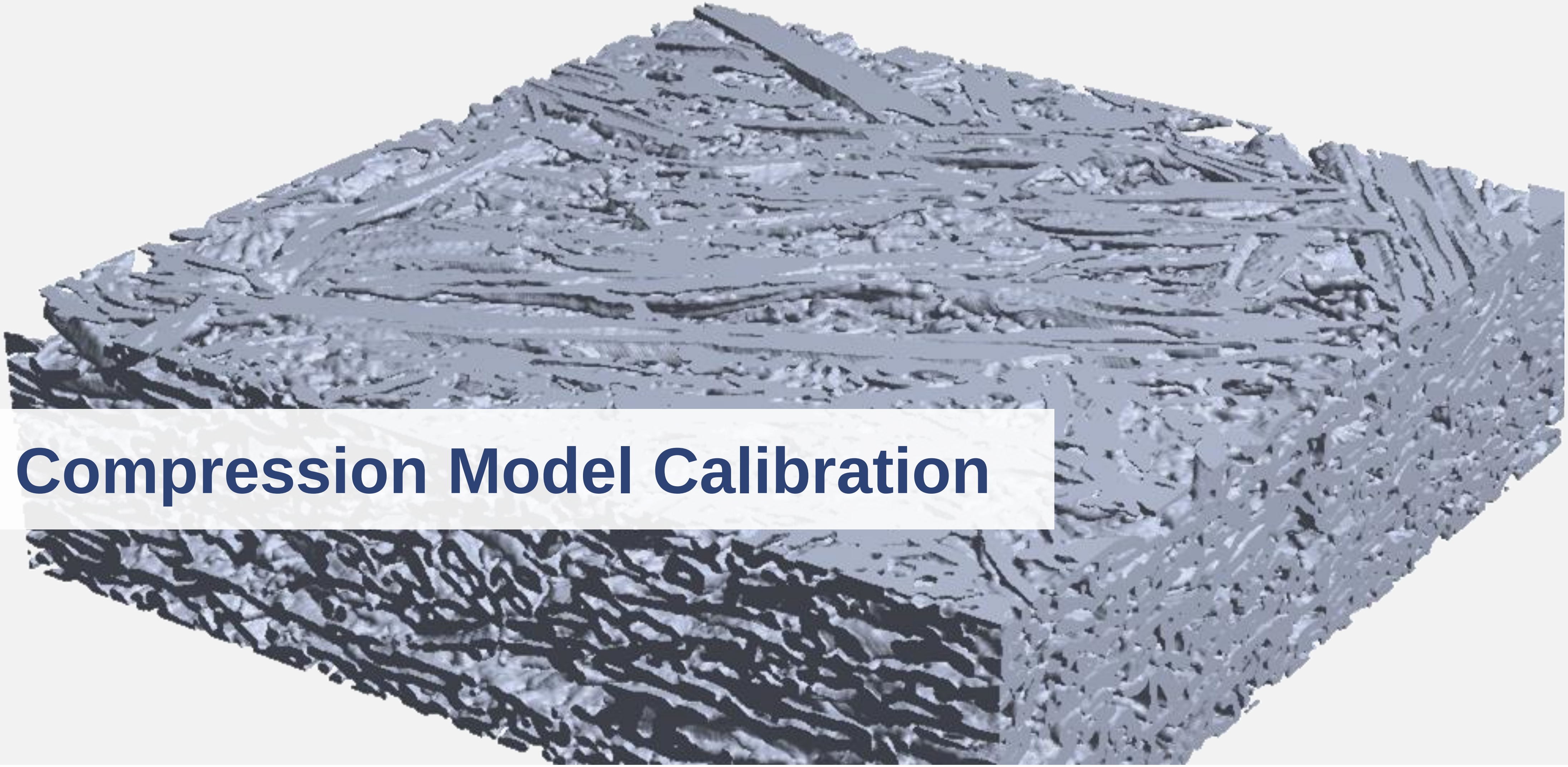


Stress on porous material causes deformation and movement of fibers



Mechanical compression model with effective physical parameters

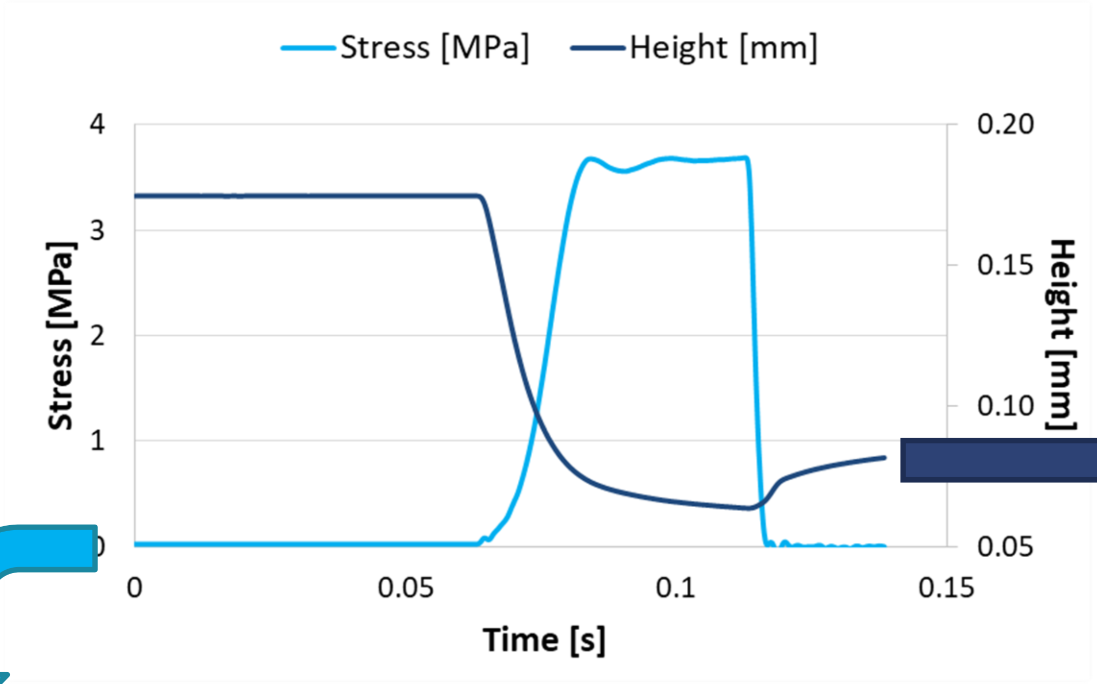
σ: total (external) stress, σ': effective stress on porous material, u: pore pressure



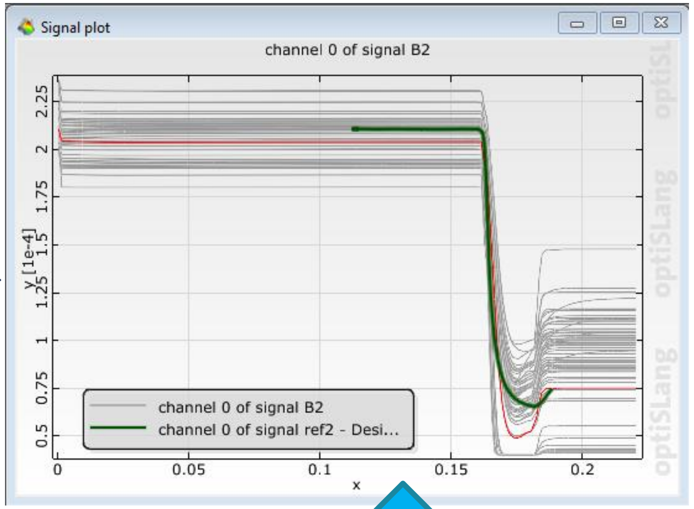
Compression Model Calibration

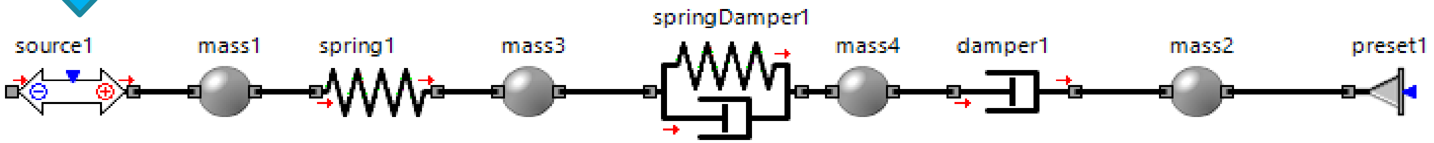
Compression Model Calibration
Calibration procedure

Dynamic compression trials of wet fiber mat

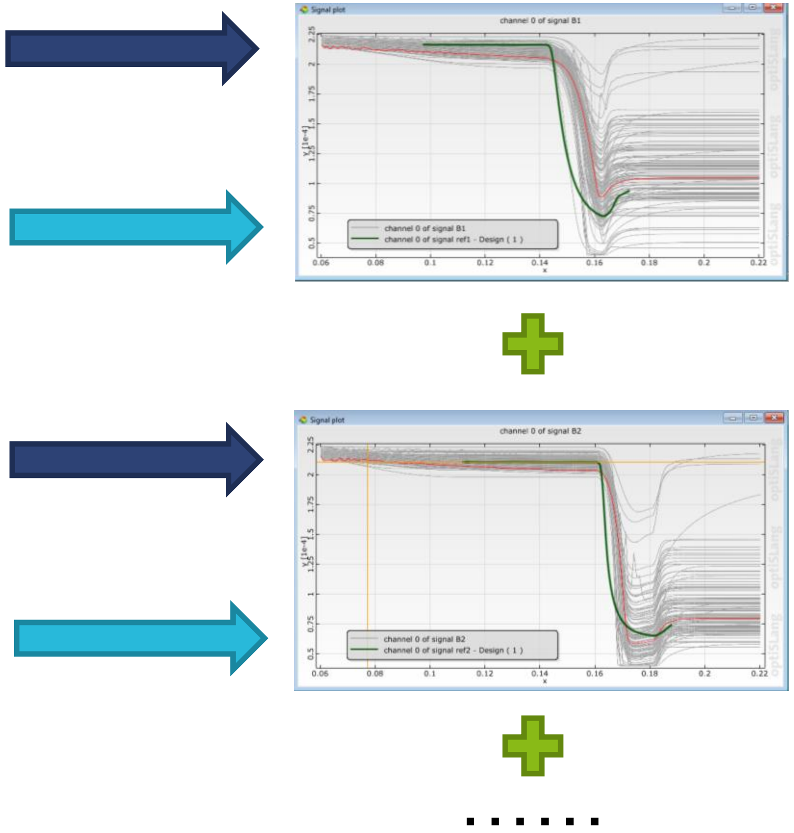


Numerical **minimization** of the difference between trial deformation and simulated deformation





Compression Model Calibration
Parallel calibration



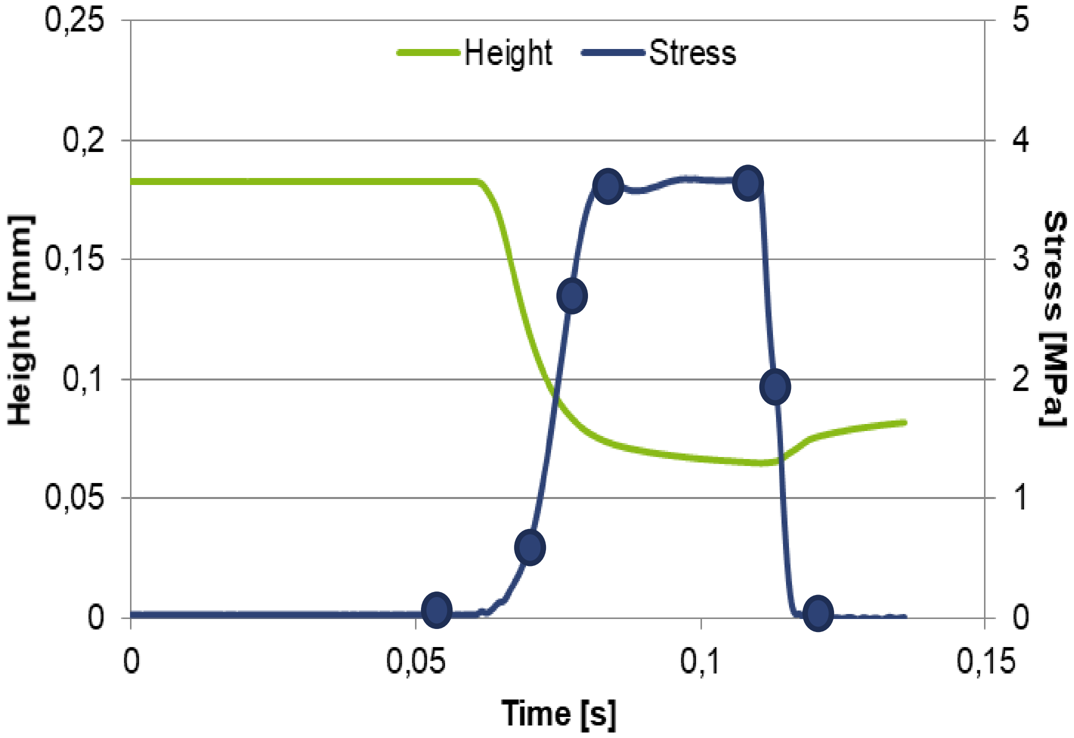
- Calibration procedure can be extended to multiple curves in parallel:

$$\min\{\sum \|d(ref_k, sim_k)\|\}$$

- Using miscellaneous curves for calibration ensures a universally valid compression model.

Press Profile Optimization

Press Profile Optimization
Approach



Parametrization of a pressure profile – Schematic drawing

- Parametrization of pressure profile using non-equidistant distributed grid points
- Numerical optimization of pressure profile:

$$\max\{DSC(p1, p2 \dots pn) : \int p_{(x)}dx = const\}$$

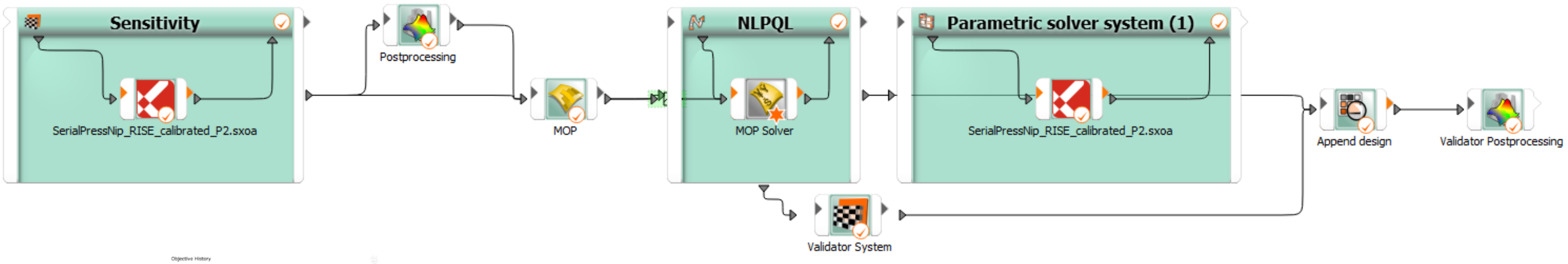
Dry solid content

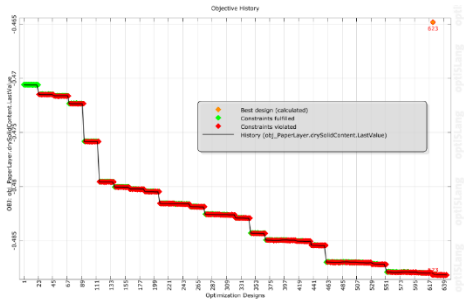
Quantifies the efficiency of the dewatering process

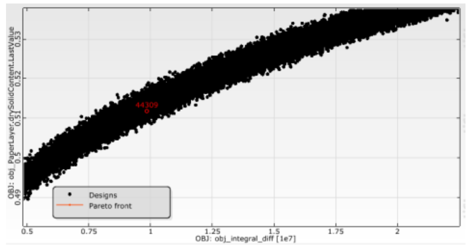
Line load

Quantifies the applied load on the paper mat

Press Profile Optimization
Implementation





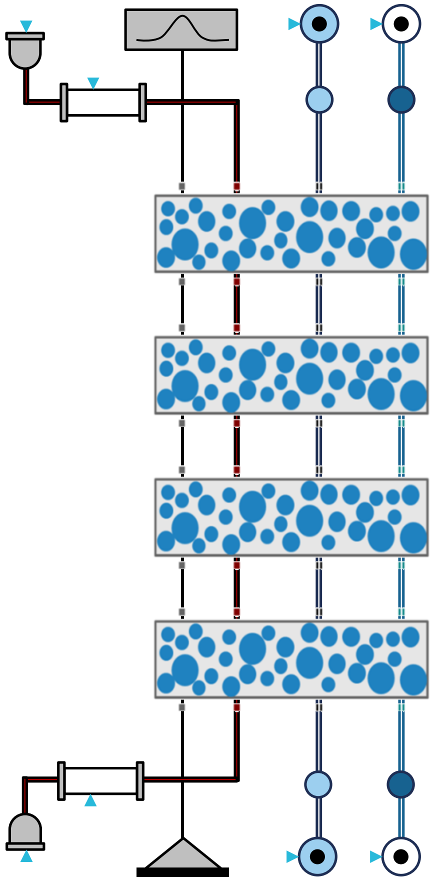


- Lineload restriction can be realized by:
  - $Lineload_{ref} \geq Lineload$ as boundary condition
  - $\min\{(Lineload_{ref} - Lineload)^2\}$ as additional objective
- Using MOP as surrogated model speeds up the optimization process with sufficient accuracy.

Summary

Summary
OptiSLang

- Using optimization capabilities of OptiSLang allows **calibration** of higly **nonlinear models**
- By **parametrizing** and **optimizing** the press profile curve (input signal) the **dryness after press** (output) can virtually significantly **increased**
- Embedding **OptiSLang** in simulation workflows **boosts** modelling as well as application projects



Thank you!

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