

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

WOST 2020

Introduction

Voith in numbers



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

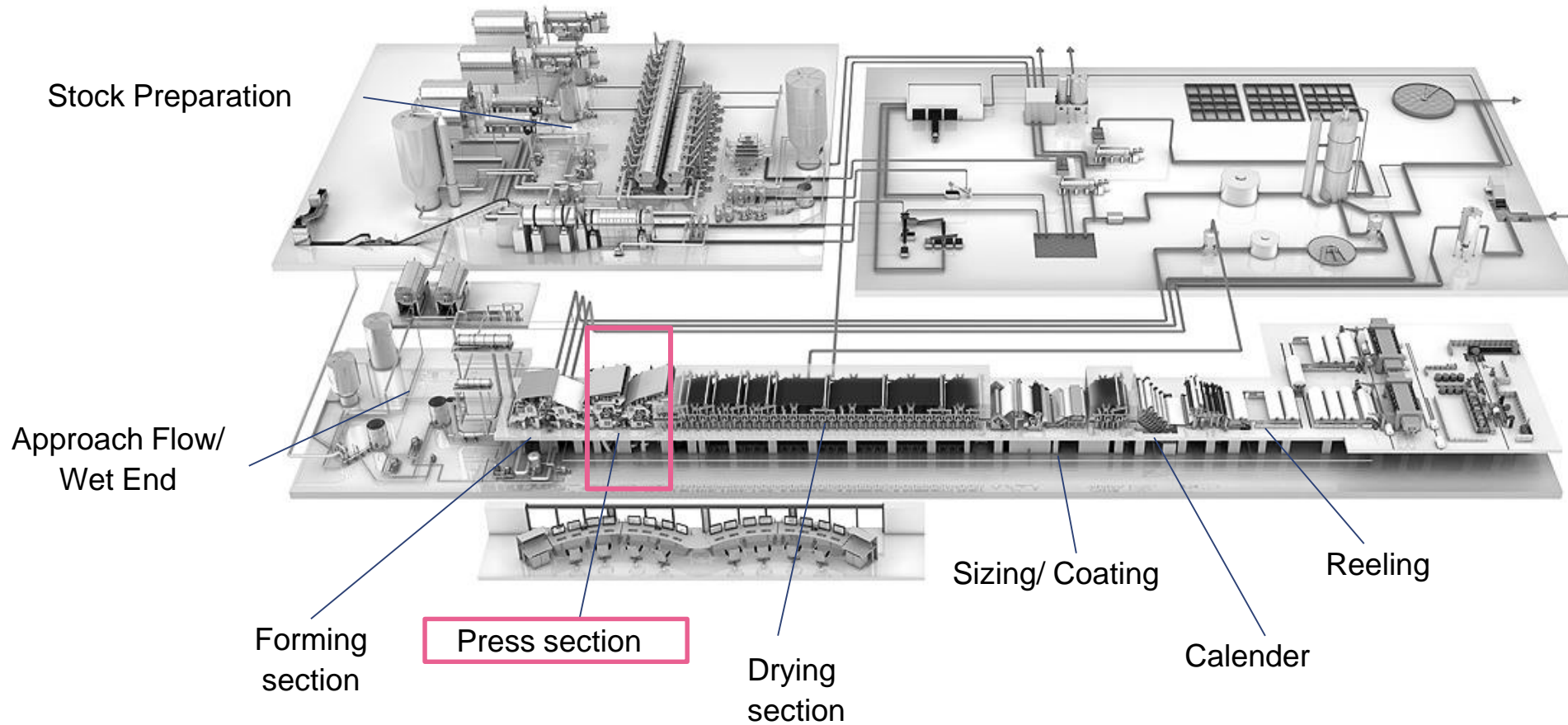
Agenda

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

A large industrial papermaking machine, specifically a Voith FP 690, is shown in a vast factory setting. The machine is a complex, multi-level structure with numerous metal walkways, railings, and stairs. It is painted in a light blue and white color scheme. The machine is situated on a highly reflective, polished floor that mirrors the structure above. In the background, the factory's high ceiling with a complex steel truss system is visible, along with other industrial equipment and a yellow overhead crane. A few workers in blue uniforms are visible in the distance on the right side of the machine.

Papermaking Process

Papermaking Process Overview

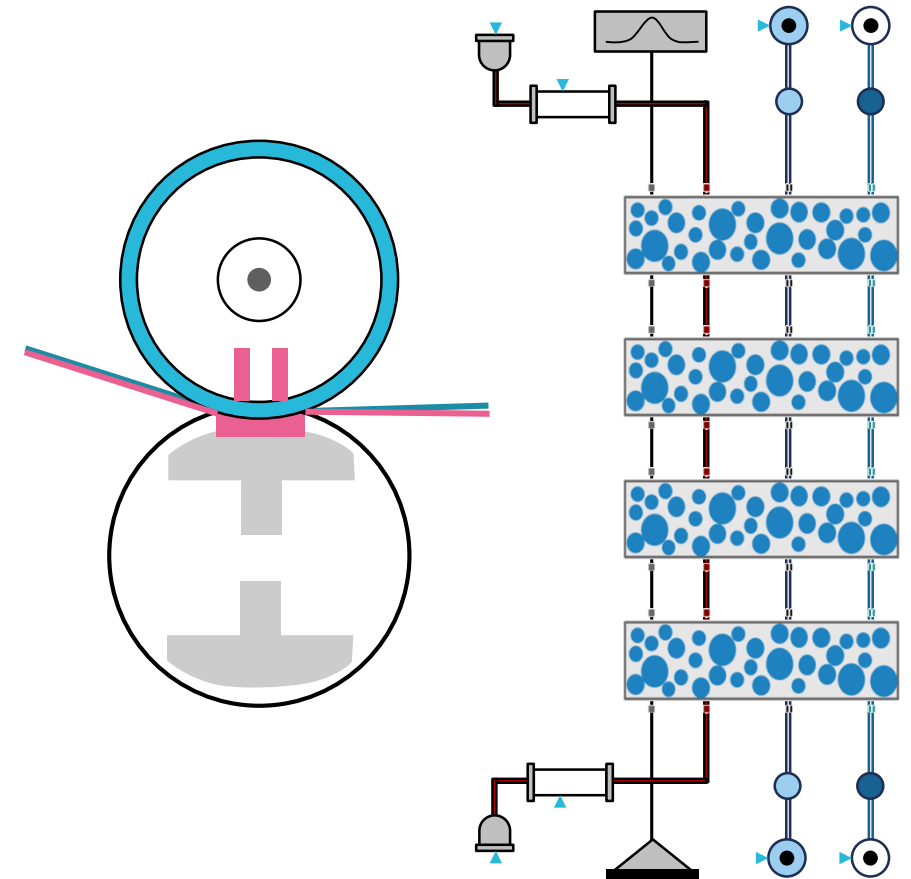




Press Model

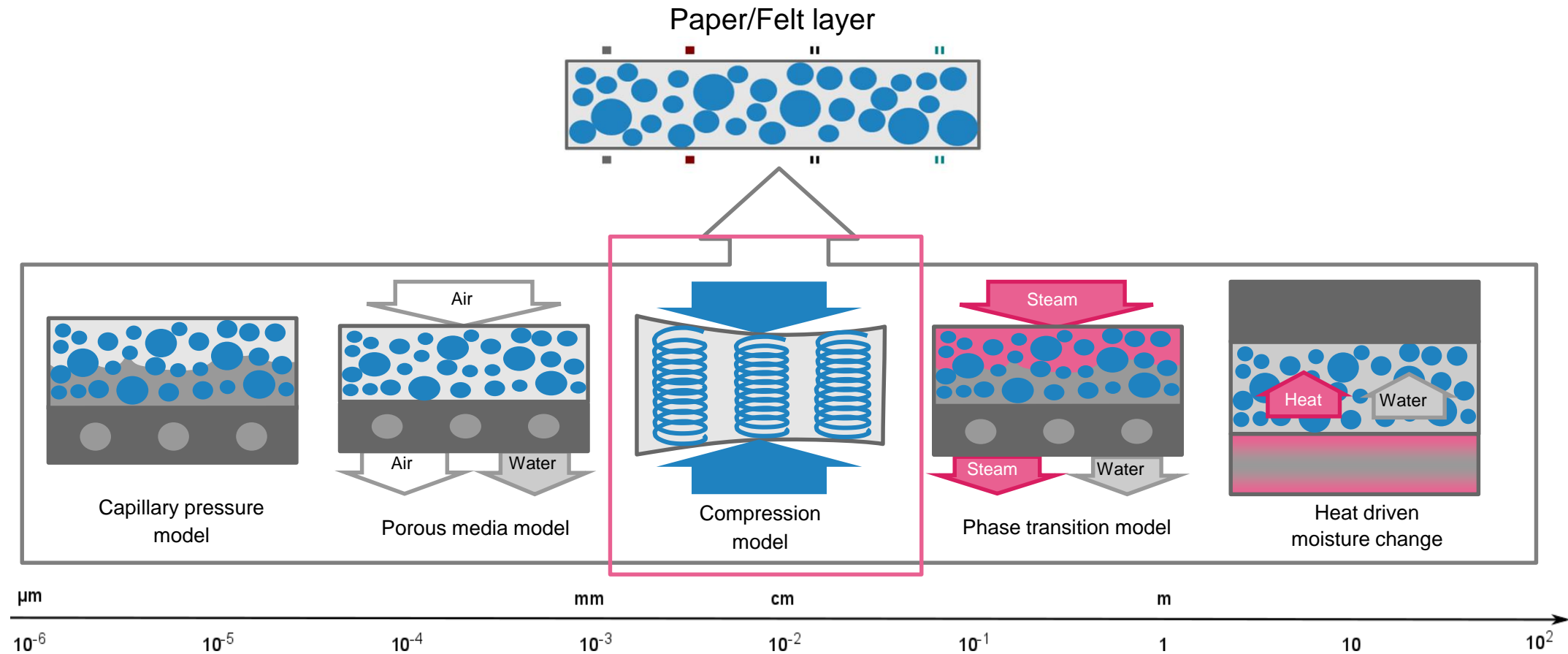
Press Model Introduction

- 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**



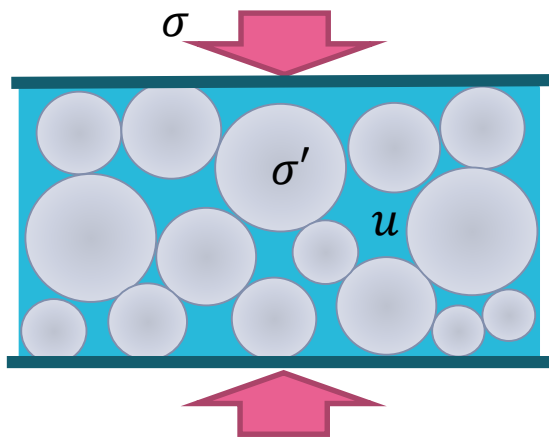
Press Model

Functional layers

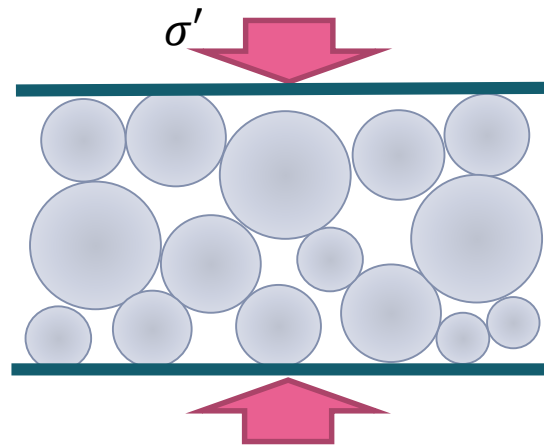


Press Model

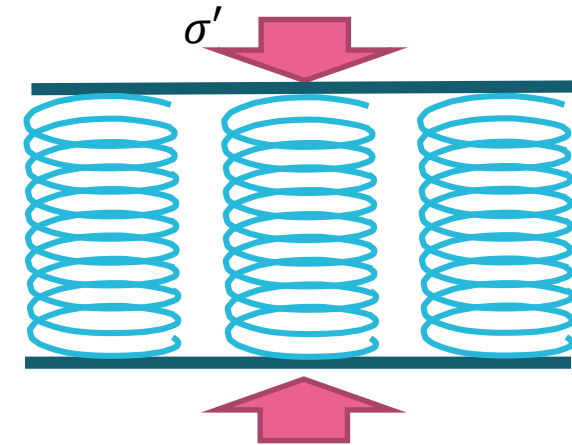
Compression Model



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

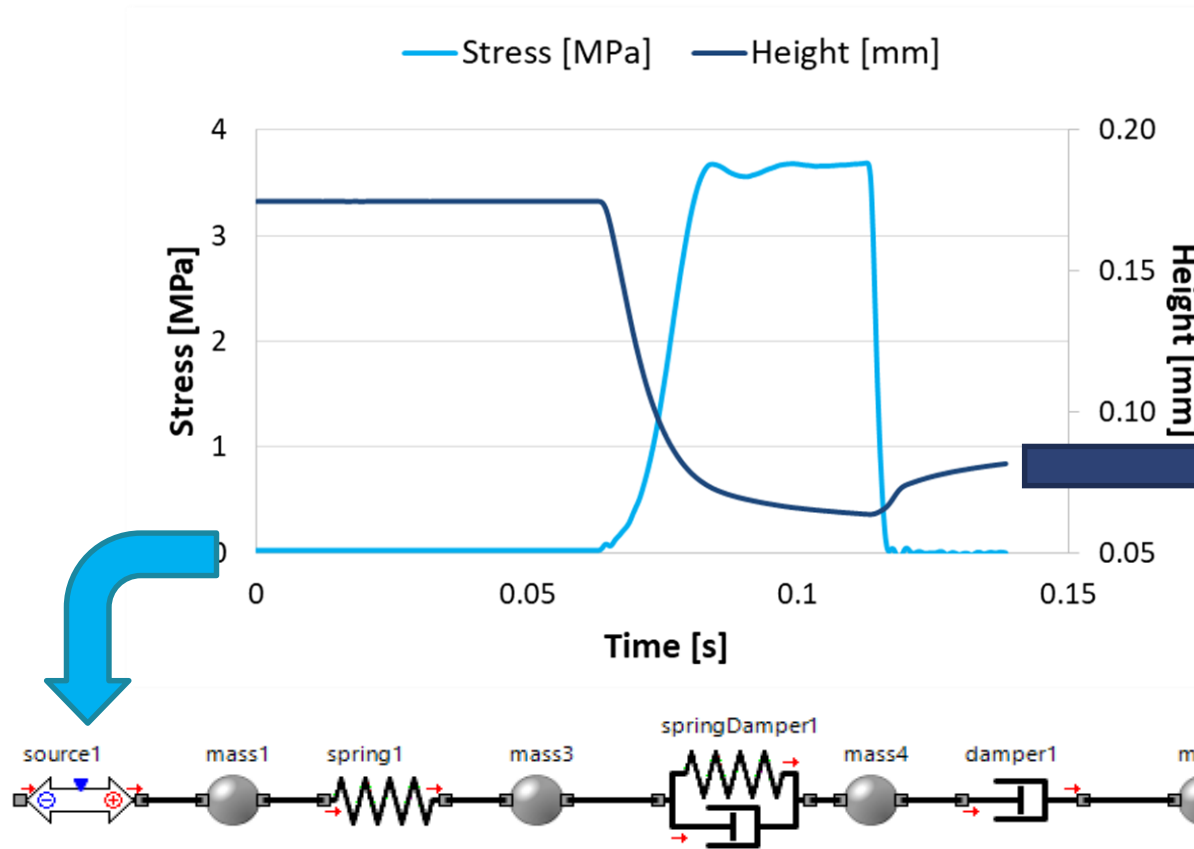


Compression Model Calibration

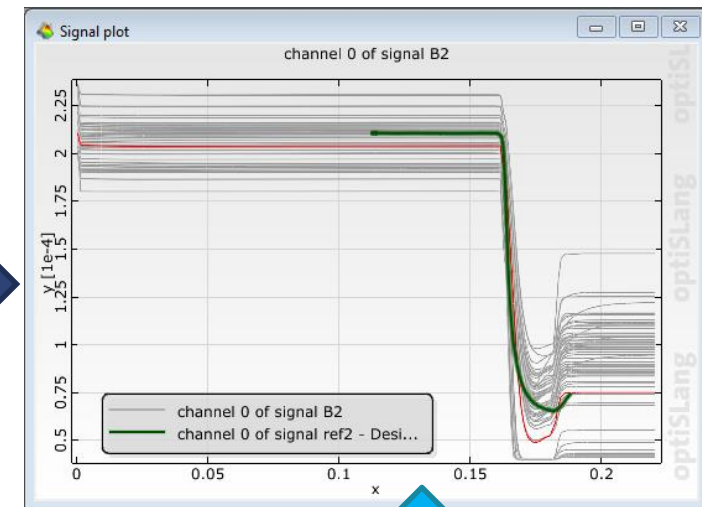
Compression Model Calibration

Calibration procedure

Dynamic compression trials of wet fiber mat

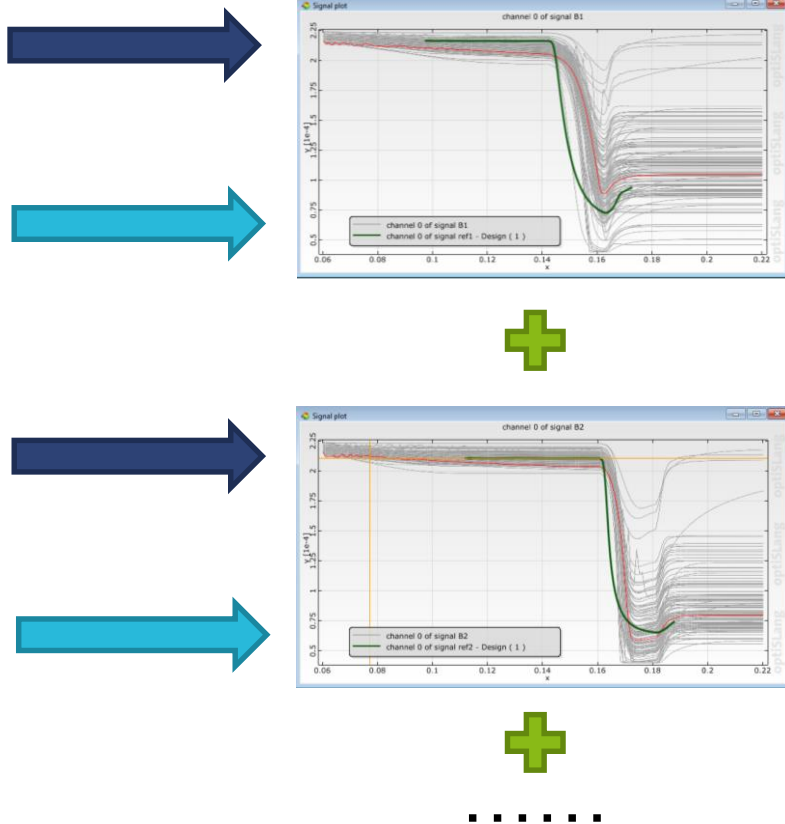


Numerical **minimization** of the difference between trial deformation and simulated deformation



Compression Model Calibration

Parallel calibration



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

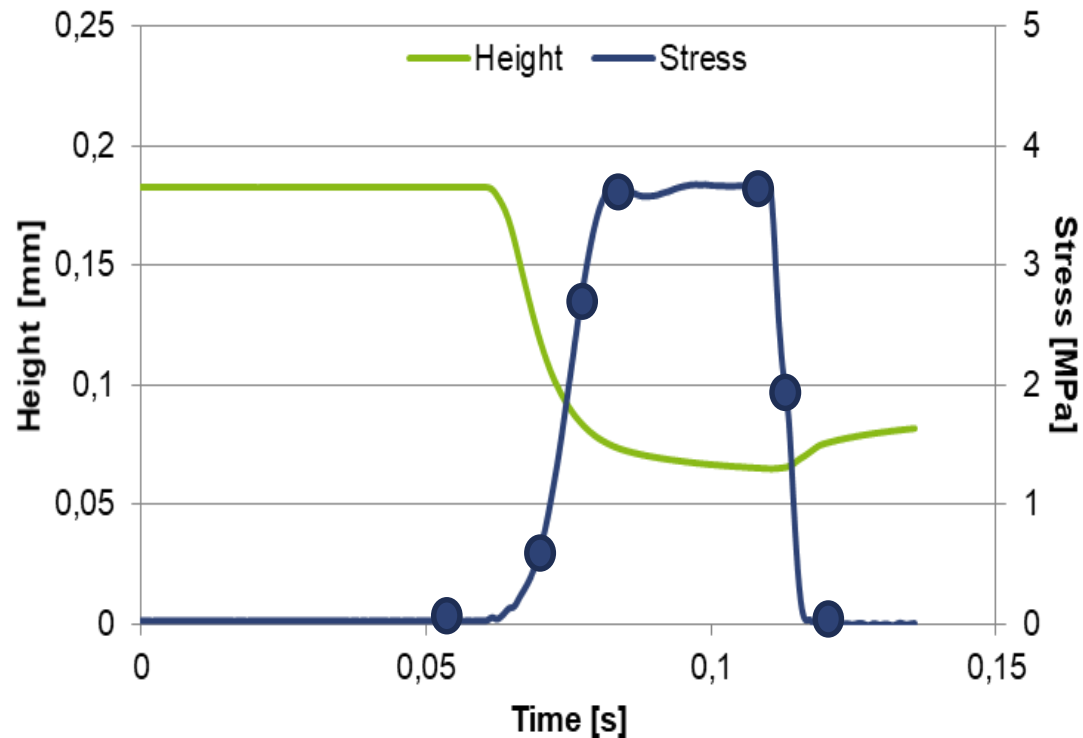
$$\min\left\{\sum \|d(ref_k, sim_k)\|\right\}$$

- 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:

$$\max\{DSC(p_1, p_2 \dots p_n) : \int p_{(x)} dx = const\}$$

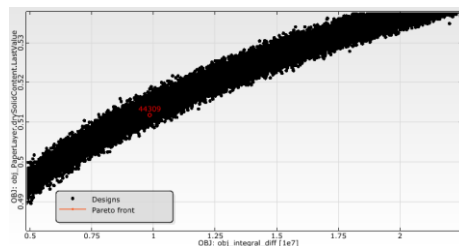
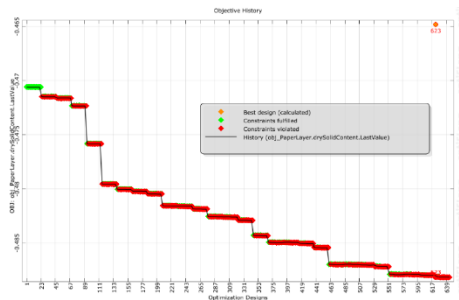
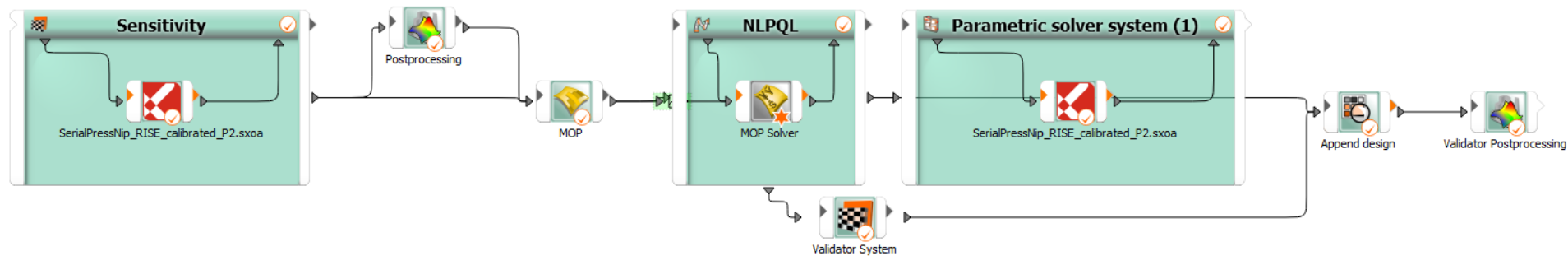
↑
Dry solid content

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.

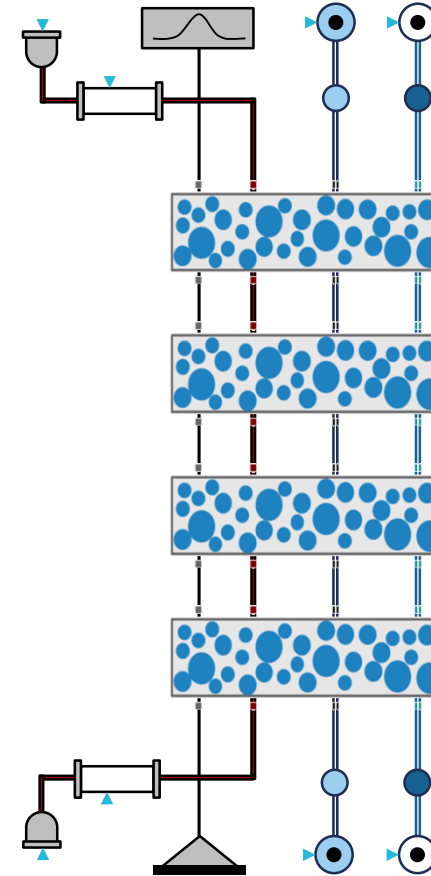
A photograph of two men standing in a factory or industrial setting. They are surrounded by large, curved rolls of white material, likely pulp or paper. The man on the left is wearing a blue work shirt, and the man on the right is wearing a white dress shirt and black trousers. They appear to be in conversation. In the background, there is a yellow sign with the number '452'.

Summary

Summary

OptiSLang

- Using optimization capabilities of OptiSLang allows **calibration** of highly **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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