TECHNISCHE UNIVERSITÄT BERGAKADEMIE FREIBERG
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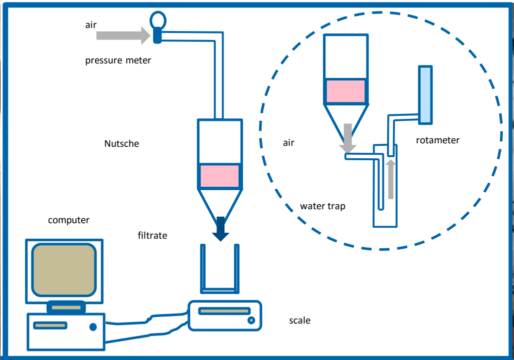
INSTITUTE OF MECHANICAL PROCESS ENGINEERING AND MINERAL PROCESSING

The effect of solid volume fraction and filter cake thickness on crack formation using conventional and steam pressure filtration






179th WISE

Thanh Hai Pham

Last 147th WISE

Permeability to investigate the appearance of cracks as well as to estimate degree of cracking

$$\text{Permeability ratio } \beta = k_G / k_L$$

Particle size distribution (is measured by Laser diffraction) and SEM pictures for **shape** of limestone particles in fine materials (KS12; x50=2.46; span 2.98) and coarse material (KS100; x50 = 20.68; span 3.88)

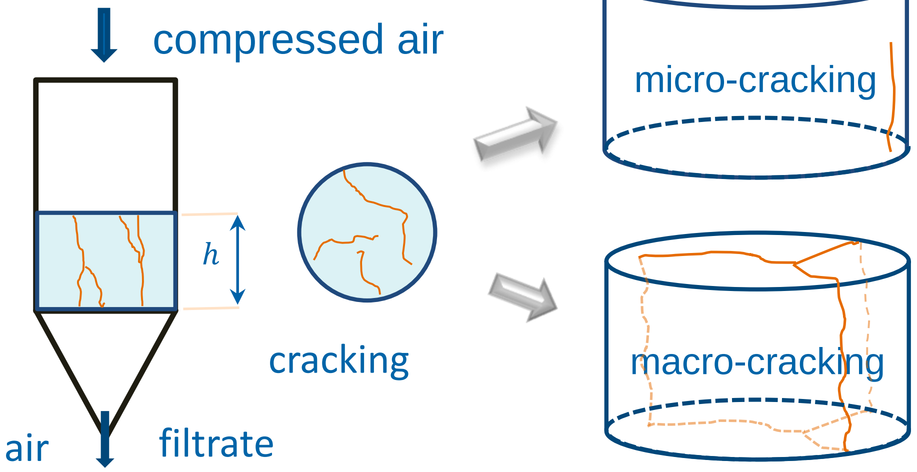
Last 147th WISE

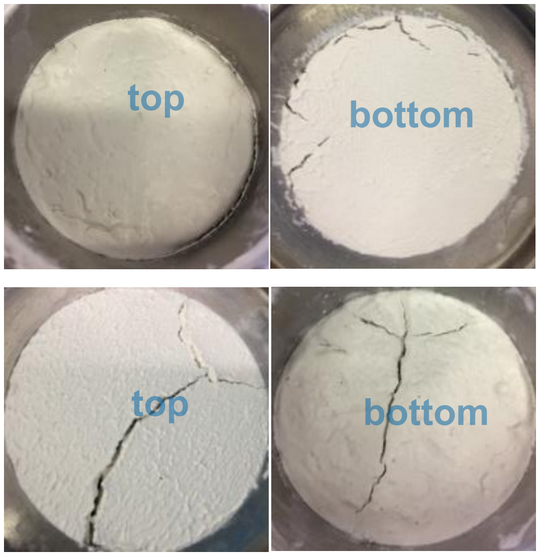
Experimental equipment: Conventional pressure filtration (was built according VDI 2762/2) and rotameters were used for all test

The effect of some input parameters (particle size distribution, solid volume fraction of suspension, height of filter cake and pressure difference) on crack formation. Tests were conducted in conventional pressure filtration

Process Net 2019

Shrinkage cracking

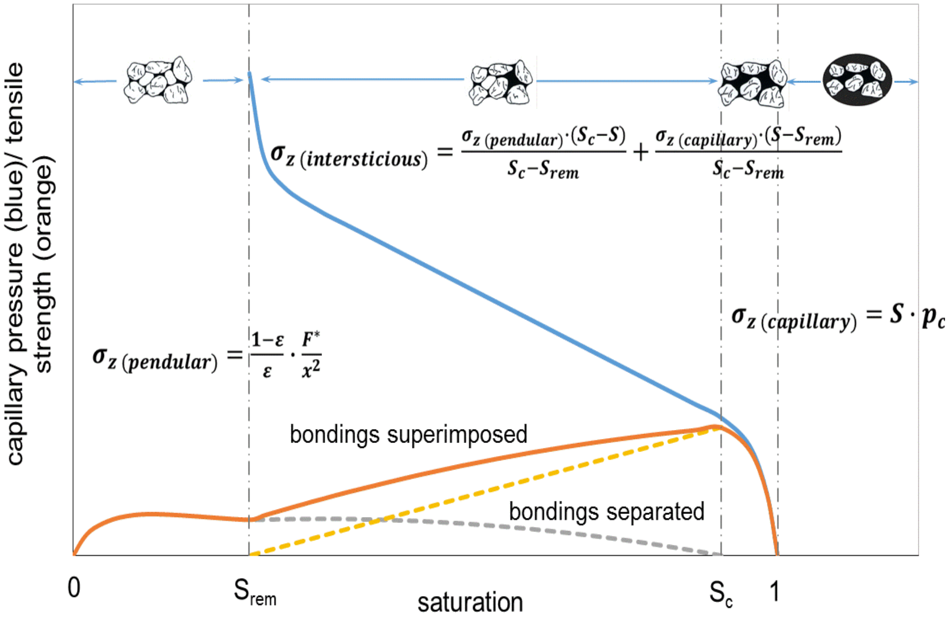




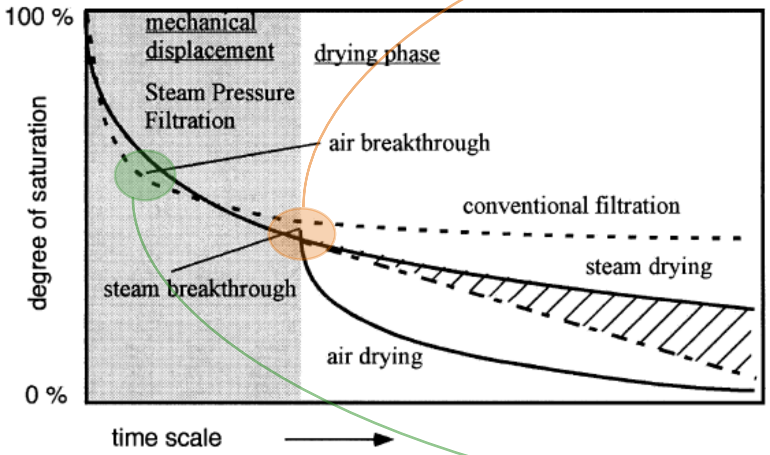
Process Net 2019

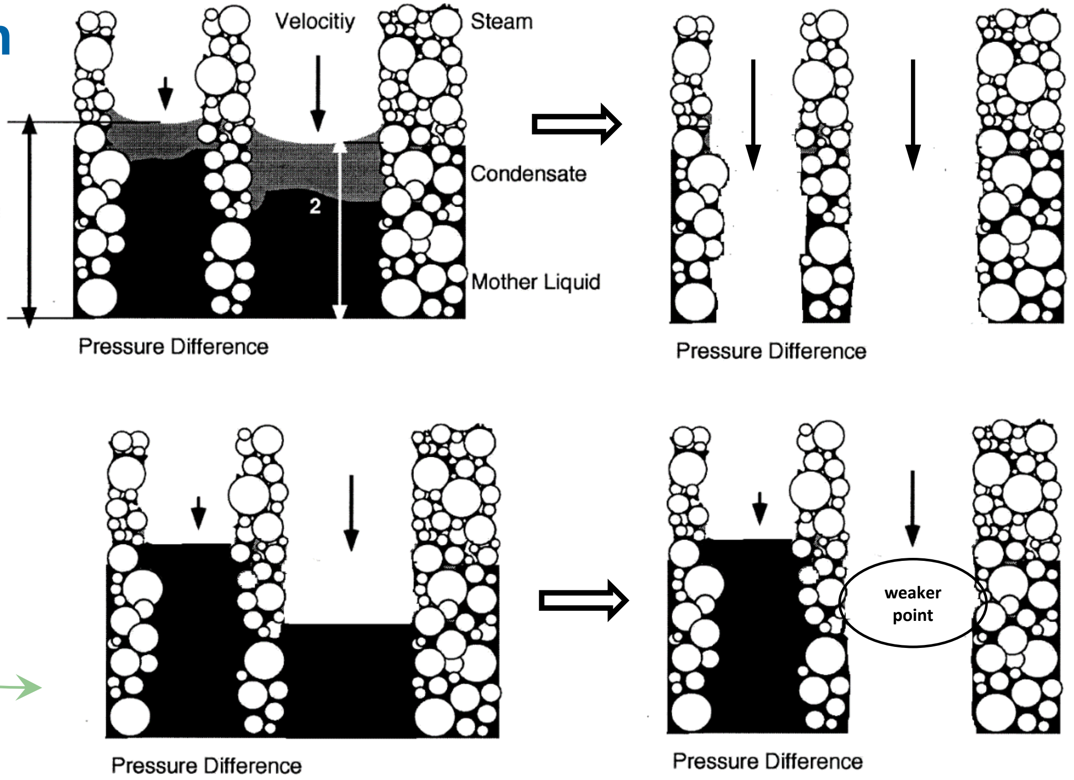
The relationship between tensile stress and saturation of filter cake. Higher tensile stress lead to the beginning of shrinkage cracking

(Schubert, Herrmann et al. 1975)



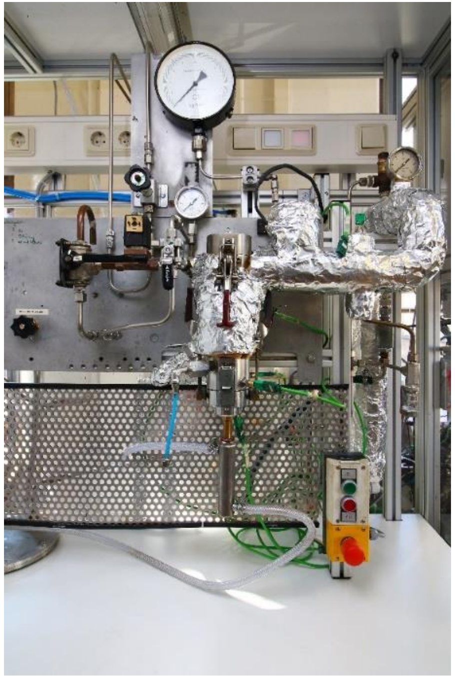
Steam pressure filtration

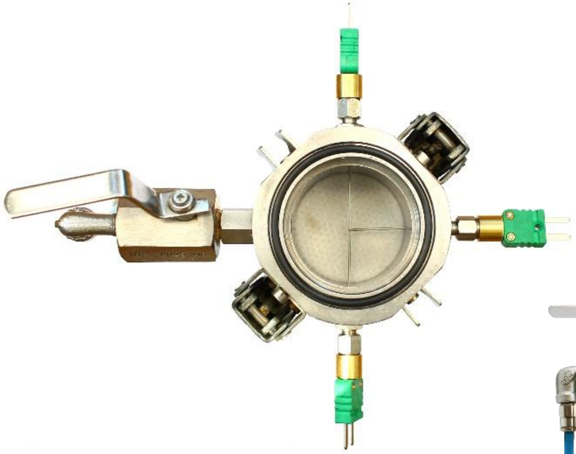




(Peuker and Stahl 2001)

Steam pressure filtration





Experimental procedure

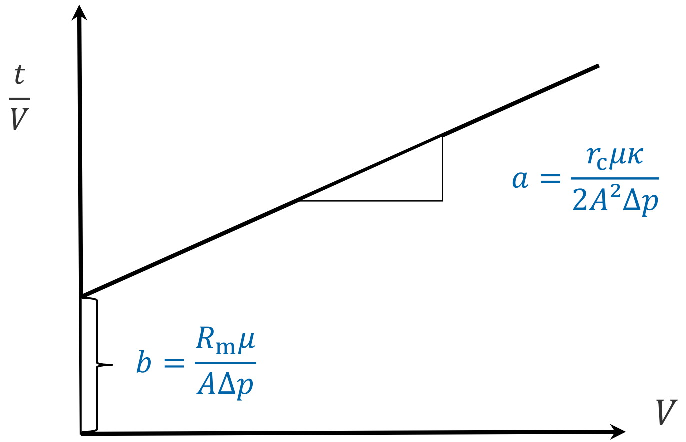
Cake formation using air pressure → Deliquoring using steam pressure → Measure the mass of water flow rate

Permeability ratio for steam pressure filtration

Permeability ratio $\beta = k_{ST}/k_L$

Liquid permeability

$$\boldsymbol{k_L = \frac{1}{r_c}}$$



$$\kappa = \frac{c_v}{1 - \varepsilon - c_v}$$

according VDI 2762

Steam permeability (need to discuss...)

case 1: deliquoring without cracks:

$$k_{ST} = \frac{k_{STm}}{k_{STrl}}$$

k_{STm} : steam permeability measured
k_{STrl} : steam raltive permeability

$$k_{STm} = \frac{2 \cdot p_2 \cdot \dot{V} \cdot \eta_{ST} \cdot h}{A \cdot (p_1^2 - p_2^2)} \quad ???$$

$$k_{STrl} = \left(1 - \left(\frac{p_b}{p_c}\right)^{\lambda}\right)^2 \cdot \left(1 - \left(\frac{p_b}{p_c}\right)^{2+\lambda}\right) \quad ???$$

p_b , p_c are the minimum pressure needed to initiate displacement of liquid and capillary pressure, respectively;

λ = 5 for practical purposes

case 2: cracks formation: k_{STm}

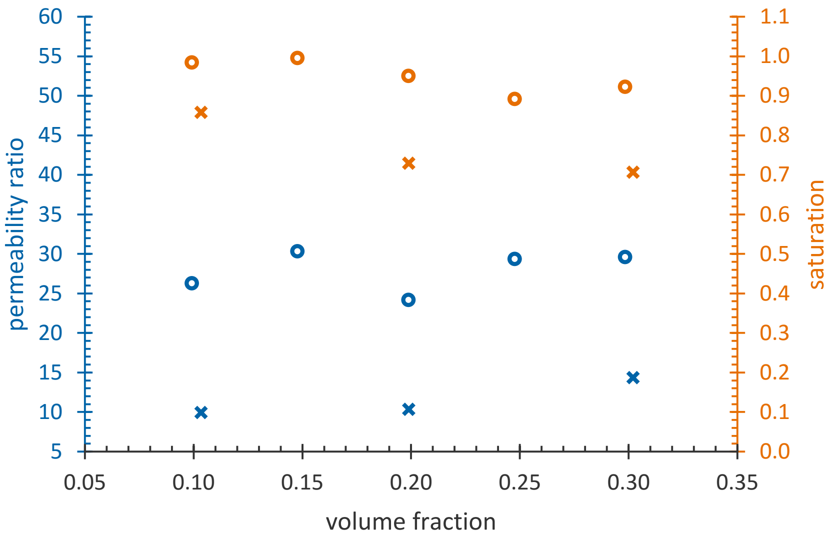
Steam permeability

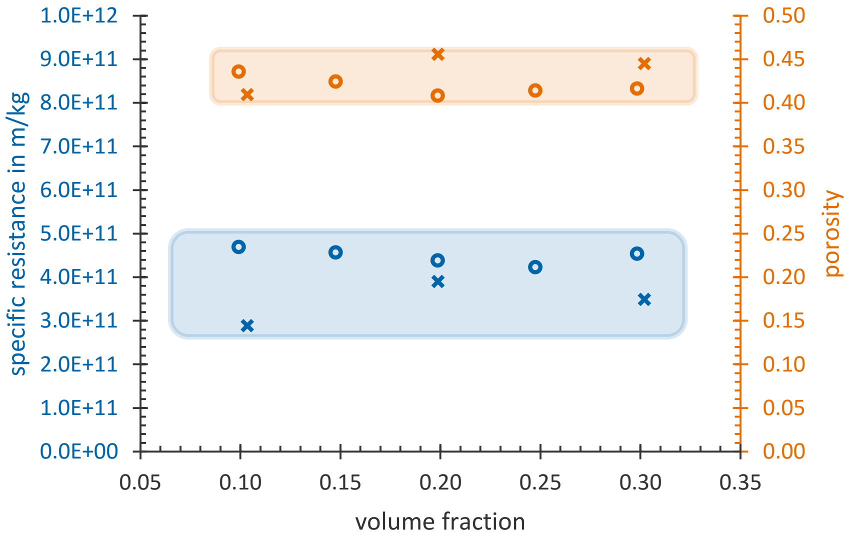
For both deliquoring with and without cracking, steam permeability is calculated:

$$k_{STm} = \frac{2 \cdot p_2 \cdot \dot{V}_2 \cdot \eta_{ST} \cdot h}{A \cdot (p_1^2 - p_2^2)}$$

The influence of volume concentration of solid on crack formation

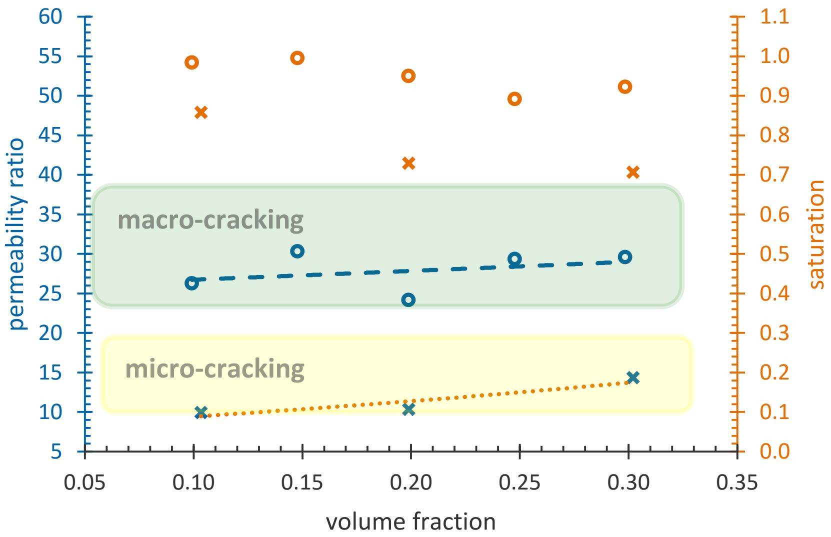
For KS12 in 3 bar (fine material)





o,x: for **conventional** pressure filtration and **steam** pressure filtration, respectively

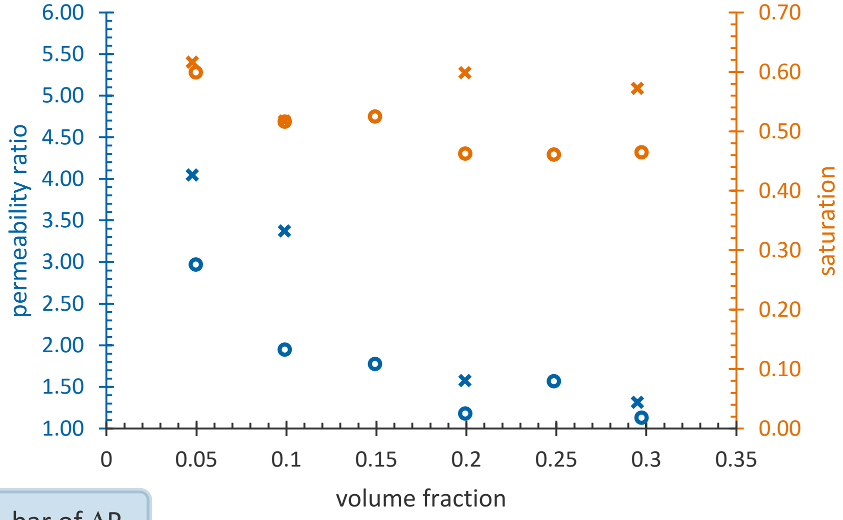
For KS12 in 3 bar (fine material)



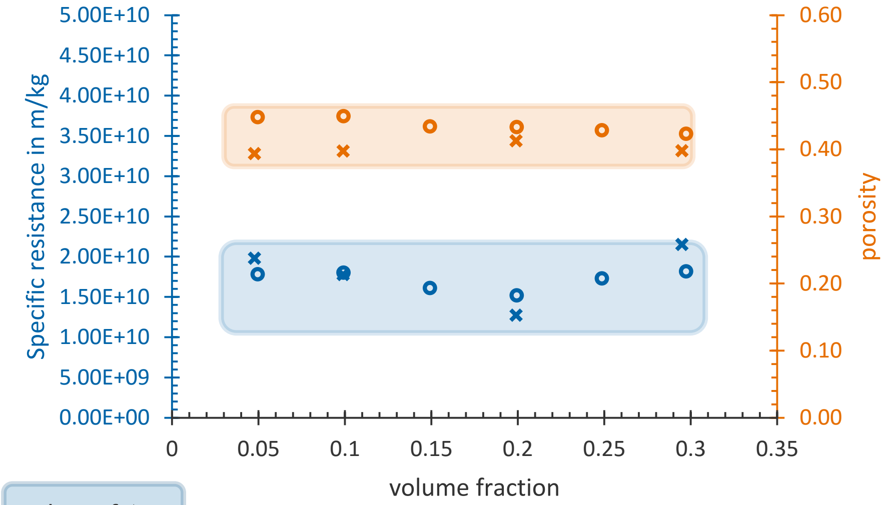
- ✓ The reduce of saturation lead to the reduction of tensile stress (lower surface tension)
- ✓ Less the weakest points
- ✓ Less the agglomerate fine grain part

o,x: for **conventional** pressure filtration and **steam** pressure filtration, respectively

For KS100 in 1 bar (coarse material)



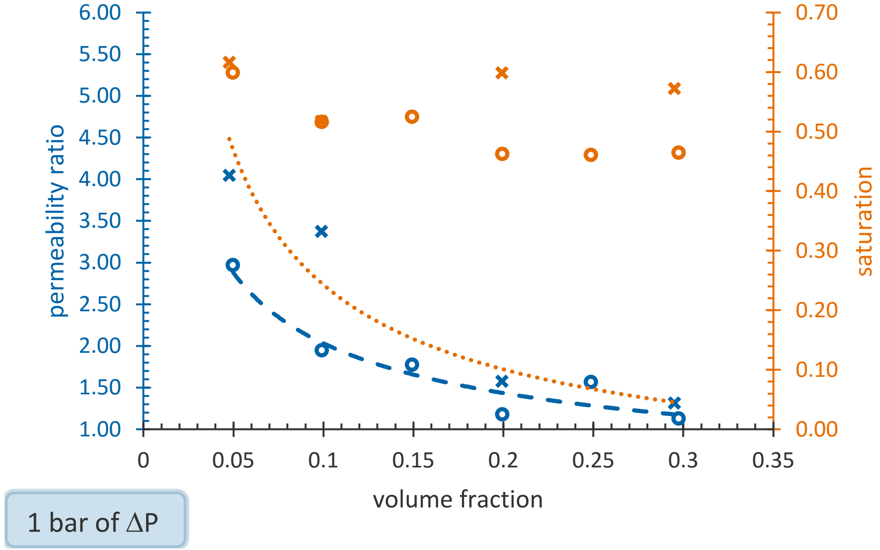
1 bar of ΔP



1 bar of ΔP

o,x: for **conventional** pressure filtration and **steam** pressure filtration, respectively

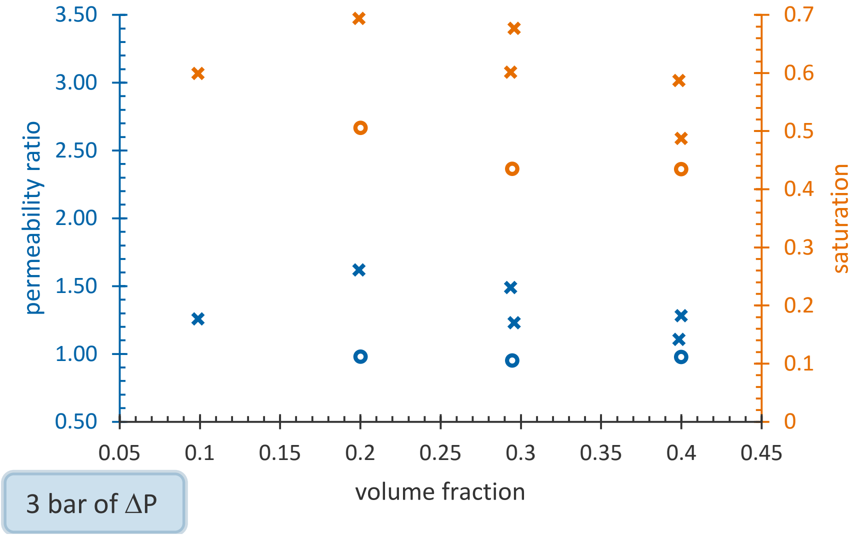
For KS100 in 1 bar (coarse material)

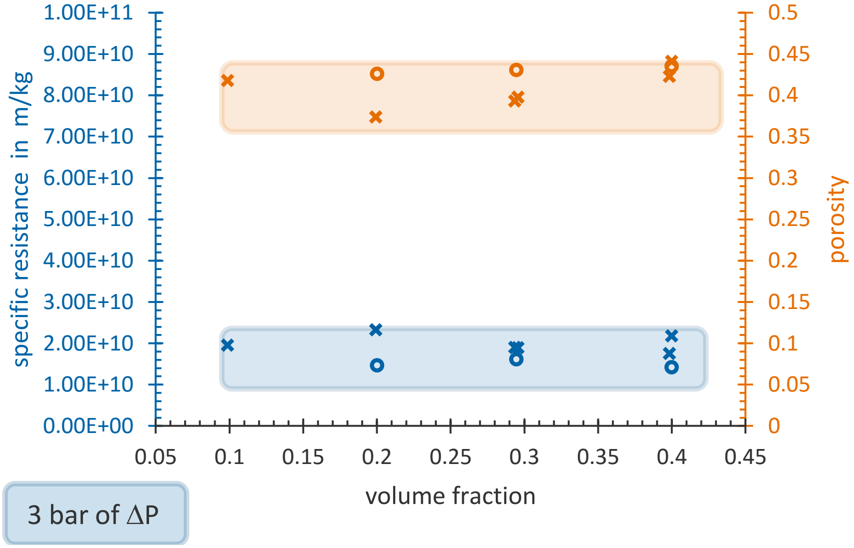


- ✓ Sedimentation dominated
- ✓ Agglomeration

o,x: for **conventional** pressure filtration and **steam** pressure filtration, respectively

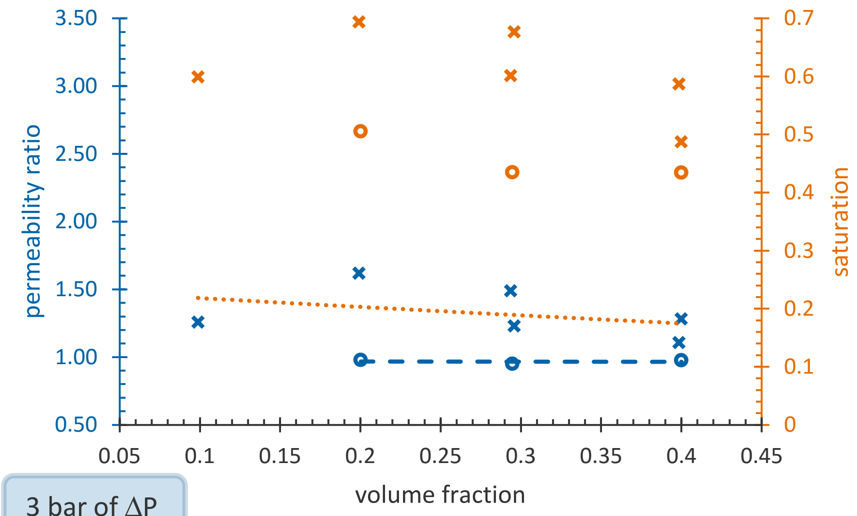
For KS100 in 3 bar (coarse material)





o,x: for **conventional** pressure filtration and **steam** pressure filtration, respectively

For KS100 in 3 bar (coarse material)



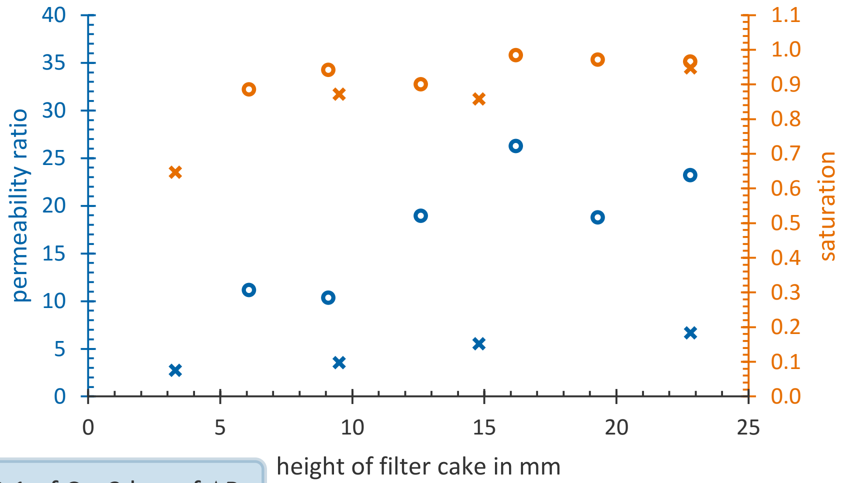
3 bar of ΔP

- ✓ No Sedimentation
- ✓ Agglomeration

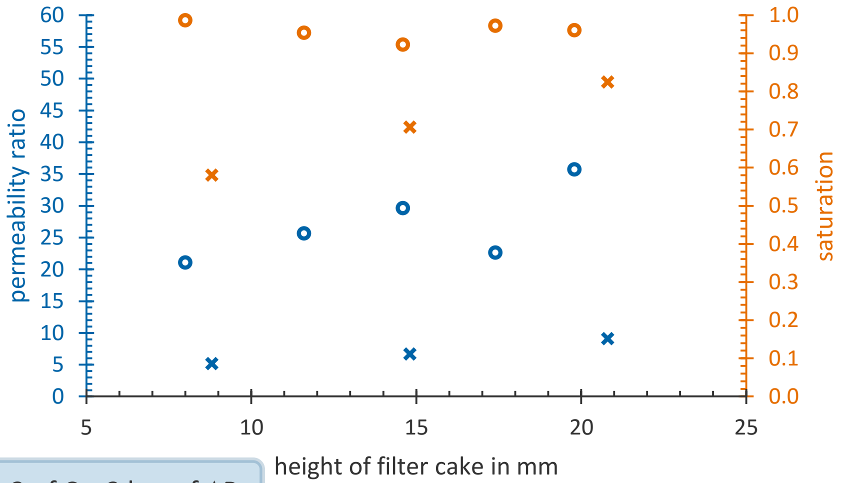
o,x: for **conventional** pressure filtration and **steam** pressure filtration, respectively

The influence of height of filter cake on crack formation

For KS12 (fine material)



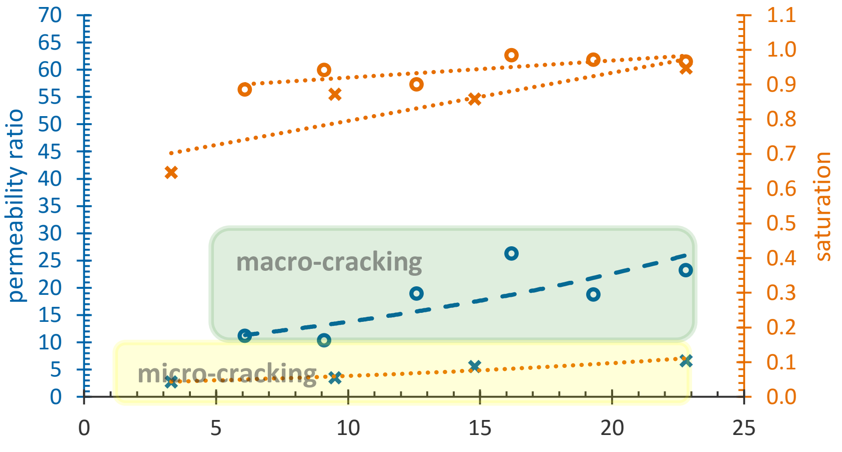
0.1 of Cv, 3 bar of ΔP



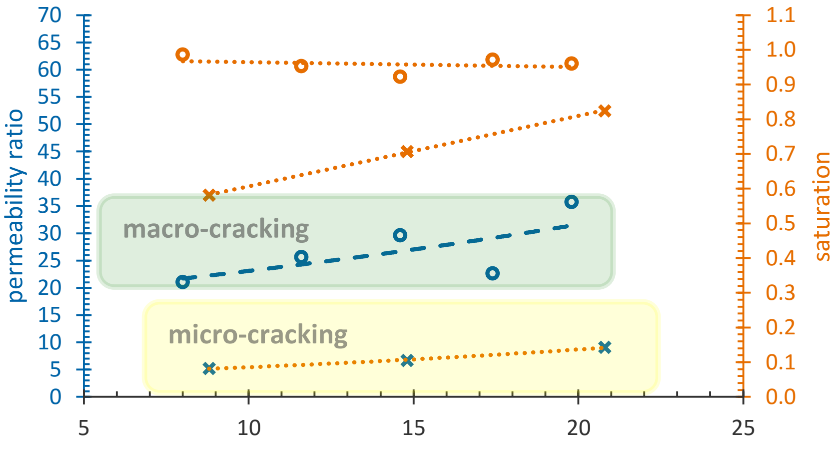
0.3 of Cv, 3 bar of ΔP

o,x: for **conventional** pressure filtration and **steam** pressure filtration, respectively

For KS12 (fine material)



0.1 of Cv, 3 bar



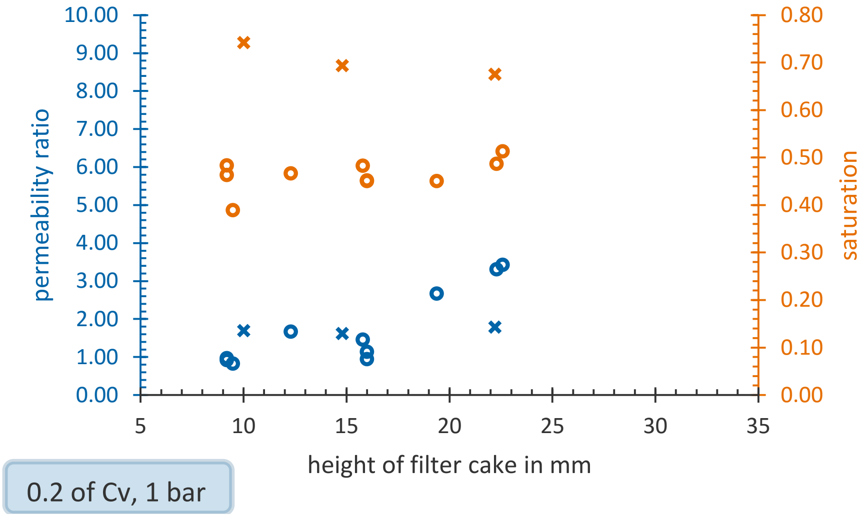
0.3 of Cv, 3 bar

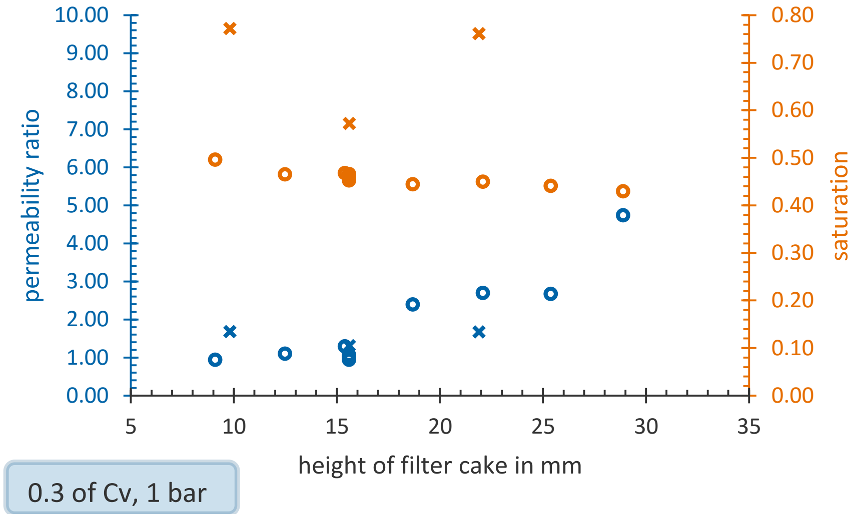
o,x: for **conventional** pressure filtration and **steam** pressure filtration, respectively

For KS12 (fine material)

- ✓ High tensile stress, the occurence of weakest point (for conventional pressure filtration)
- ✓ Agglomeration fine part (for conventional pressure filtration)
- ✓ Low transferability of stress to filter cloth (for both)
- ✓ Wall side friction (for both)

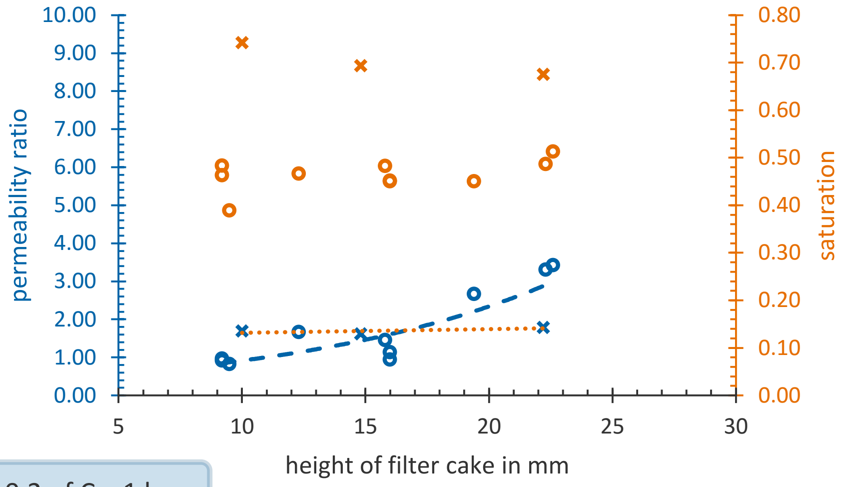
For KS100 (coarse material)



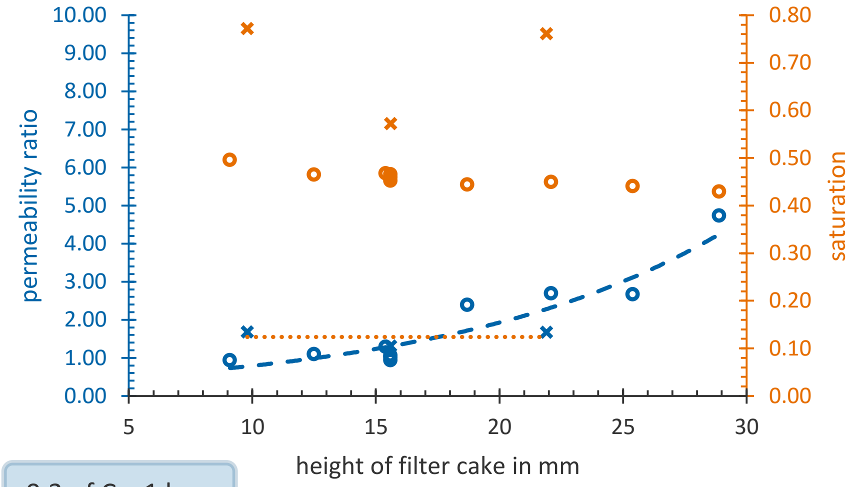


o,x: for **conventional** pressure filtration and **steam** pressure filtration, respectively

For <u>KS100</u> (coarse material)



0.2 of Cv, 1 bar



0.3 of Cv, 1 bar

o,x: for **conventional** pressure filtration and **steam** pressure filtration, respectively

For KS100 (coarse material)

- ✓ Agglomeration fine part (for conventional pressure filtration)
- ✓ Low tranferability of stress to filter cloth (for both)
- ✓ Wall side friction (for both)

Discussion

- Calculation permeability for steam without taking into relative permeability;
- The reason for cracking may be:
  - Tensile stress of particles in filter cake (macro-. microcracking, shrinkage)
  - Agglomeration of fine grain part (micro-cracking, shrinkage)
  - Wall size friction (micro-cracking, shrinkage)
  - The transferability of stress to filter cloth (micro-cracking, shrinkage)
- Steam pressure filtration reduce the probability as well as degree of macro-cracking during deliquoring

Next time

- ✓ Vietnam coal sampling on August (very late according plan- on December last year)
- ✓ Complete tests with new material, focus on crack formation and the efficiency of coal dewatering
- ✓ Collect data, analyse and write down PhD Thesis

Thank you for your attention!

Danke für Ihre Aufmerksamkeit!

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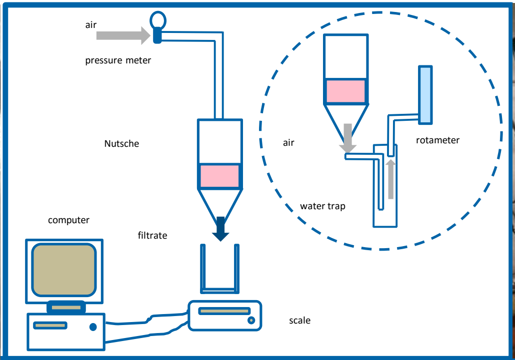
Comparation about the effect of volume fraction on crack formation in conventional and steam pressure filtration



175th WISE

Thanh Hai Pham