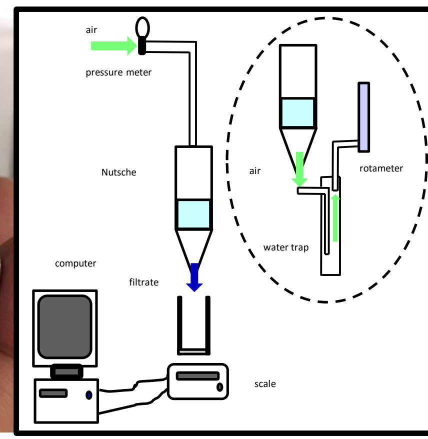
The effect of some parameters on cracks formation



MSc. Thanh Hai Pham

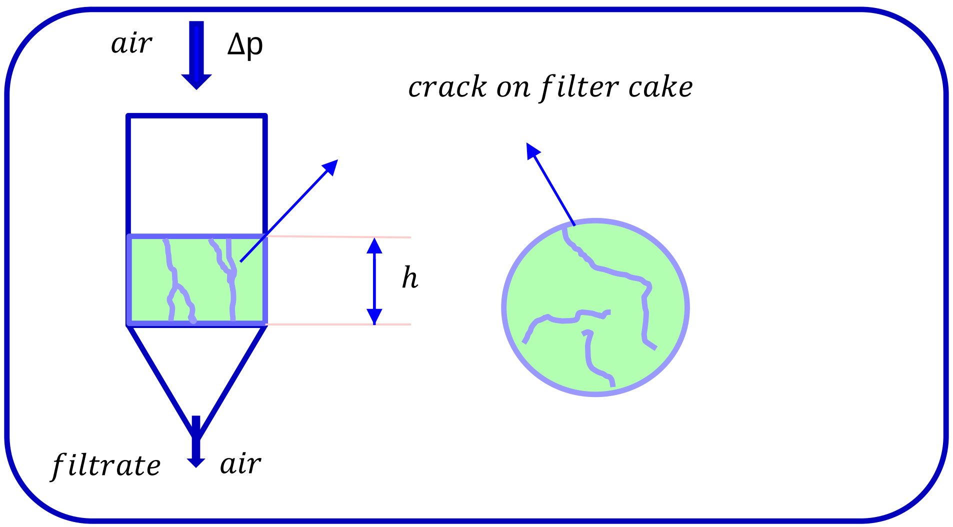
The effect of some parameters on cracks formation

Motivation and method

The crack is formed during filtration and washing process and is the undesired phenomenon

This phenomenon lead to:

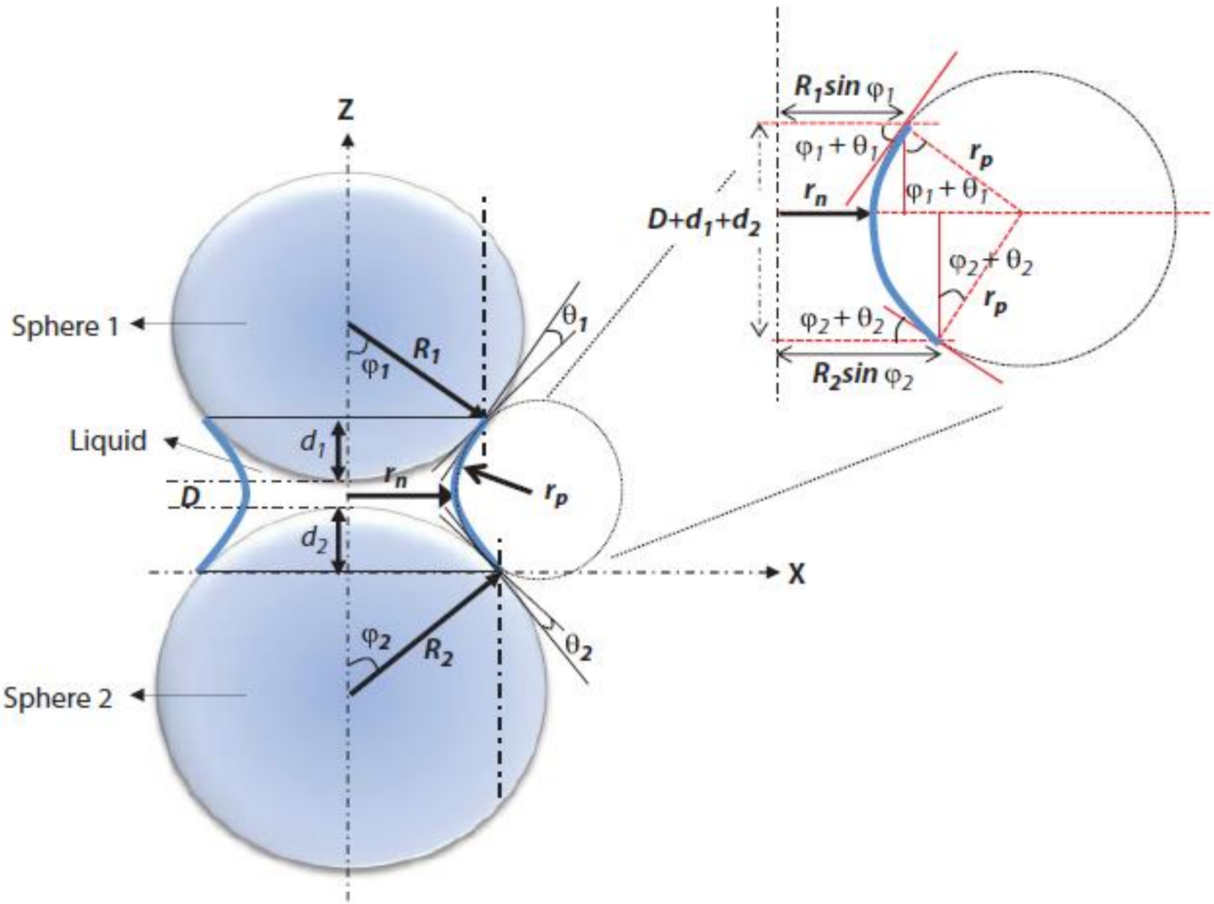
- Higher gas/water washing consumption
- A decrease in filtration pressure
- Higher residual moisture content, the filtrate is less purity



⇒ Objective: Quantification of cracks on filter cake and methods to avoid cracks.

I. Motivation and method

The formation of crack is generally caused by the shrinkage of the filter cake, which is a result of the action of capillary force (Wiedemann and Stahl 1996)



I. Motivation and method

Total capillary force between two spheres linked by liquid bridge:

$$F_{cp} = A_{xy}\gamma_l\left(\frac{1}{r_p}+\frac{1}{r_n}\right) = \pi r_c^2\gamma_l\left(\frac{\cos(\theta_1+\varphi_1)+\cos(\theta_2+\varphi_2)}{D+d_1+d_2}+\frac{1}{r_n}\right)$$

For large spheres (R_1 and R_2 >>> D and R_1 and R_2 >>> d):

$$F_{cp}^{R_1,R_2\gg D,\,R_1,R_2\gg d} = \pi r_c^2\gamma_l\left(\frac{cos(\theta_1)+cos(\theta_2)}{D+d_1+d_2}\right)$$

If both spheres are identical:

$$F_{cp}^{R\gg D,R\gg d} = \frac{2\pi R\gamma_l cos(\theta)}{1+D/2d}$$

Stephen Beaudoin1, P. J., Aaron Harrison1, Jennifer Laster1, and M. S. Kathryn Smith1, and Myles Thomas1 "Fundamental Forces in Particle Adhesion." (Particle adhesion and removal).

I. Motivation and method

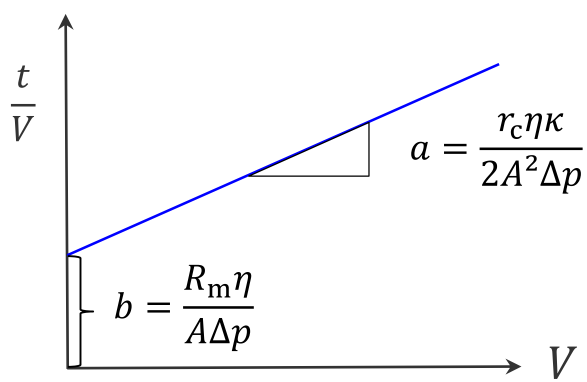
Permeability ratio $\beta = \frac{K_G}{K_L} = r_c * K_G$

$$K_L = \frac{1}{r_c}$$

$$r_c = \frac{a.2.\Delta p.A^2}{\eta_L.\kappa}$$

$$K_G = \frac{2(p * \dot{V})_t * \eta_G * h}{A * (p_1^2 - p_2^2)}$$

[Wyckoff et al]

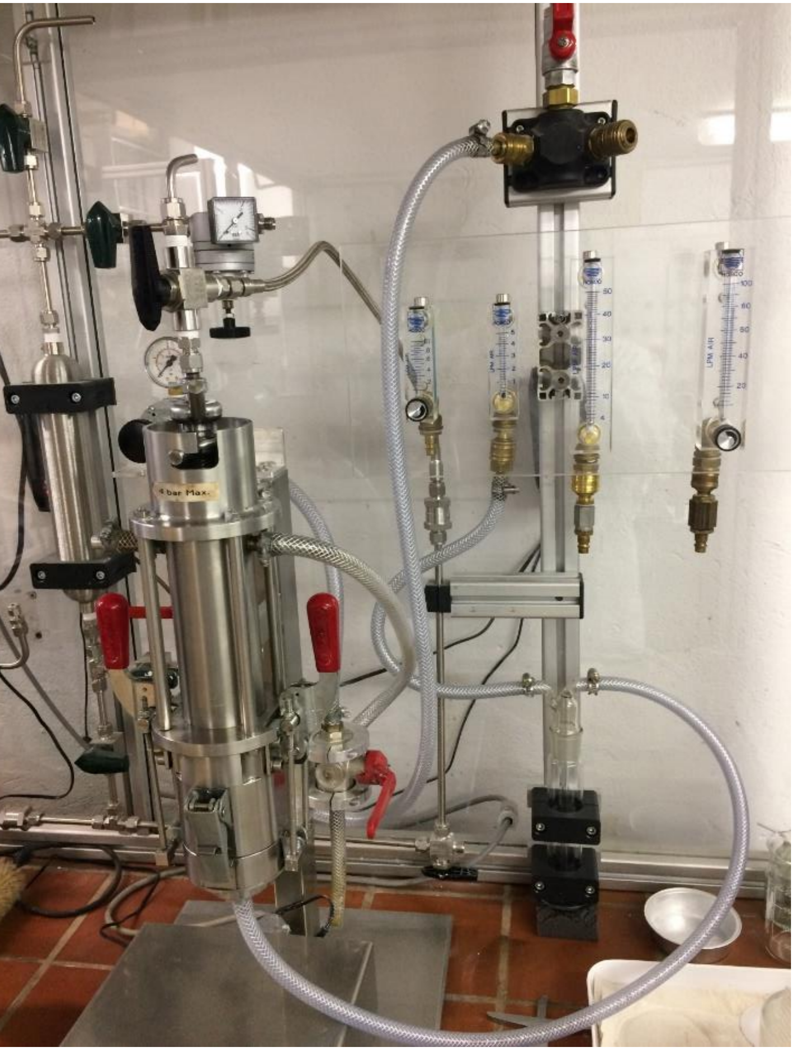


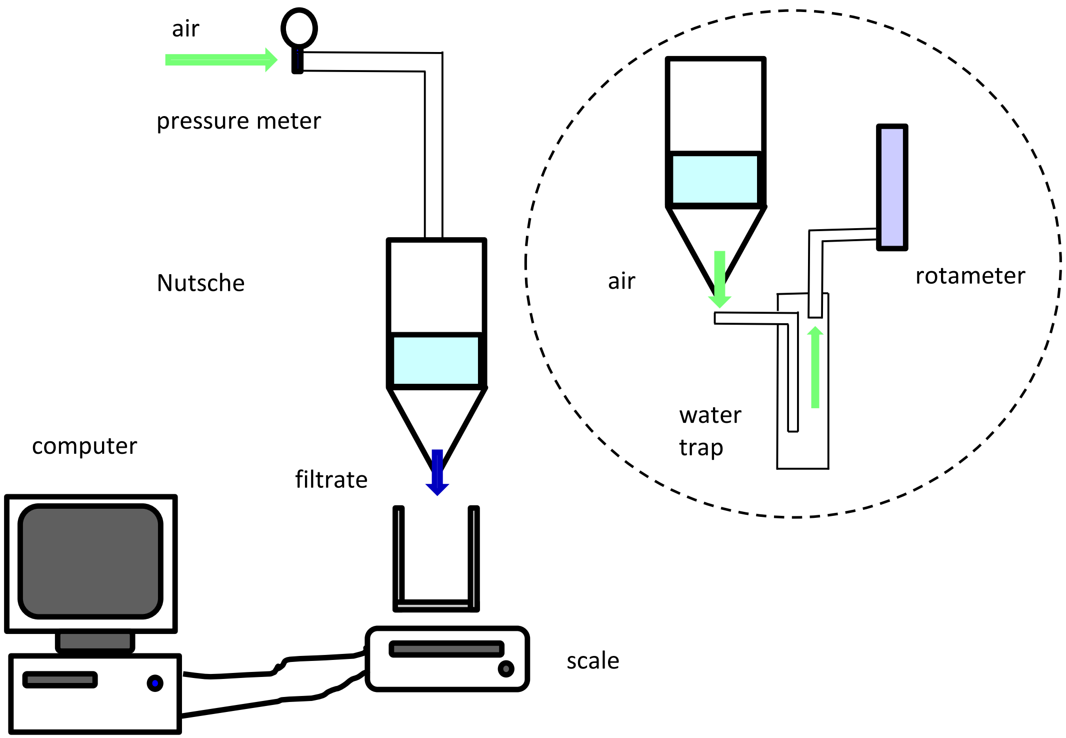
$$\kappa = \frac{c_v}{1 - \varepsilon - c_v}$$

Residual moisture content (M)

$$M = \frac{m_{liquid}}{m_{wet\ in\ filter\ cake}} * 100\%$$

II. Experiment equipment and materials





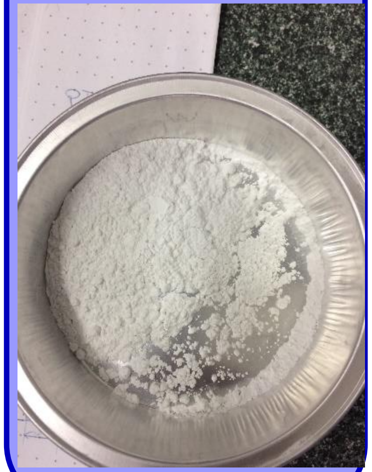
II. Experiment equipment and materials

The materials for tests are limestones with different median size

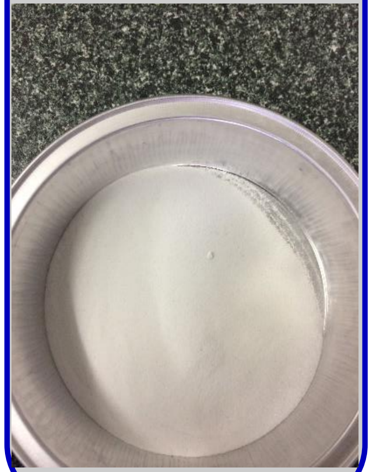
KS < 12 µm
(x_{50} = 2.46 µm)

KS < 120 µm
(x_{50} = 17.93 µm)

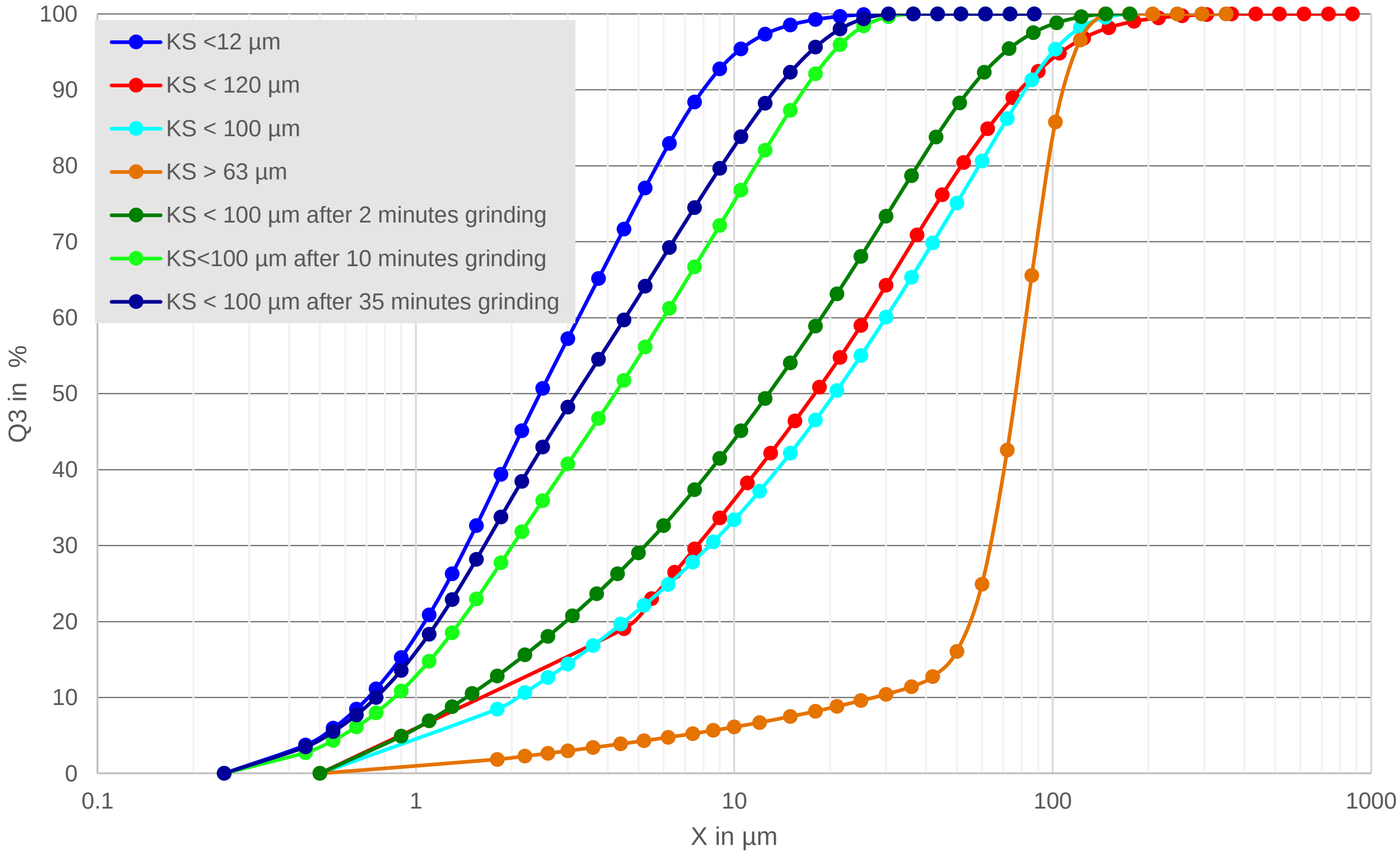
KS < 100 µm
(x_{50} = 20.68 µm)



KS > 63 µm
(x_{50} = 76.53 µm)



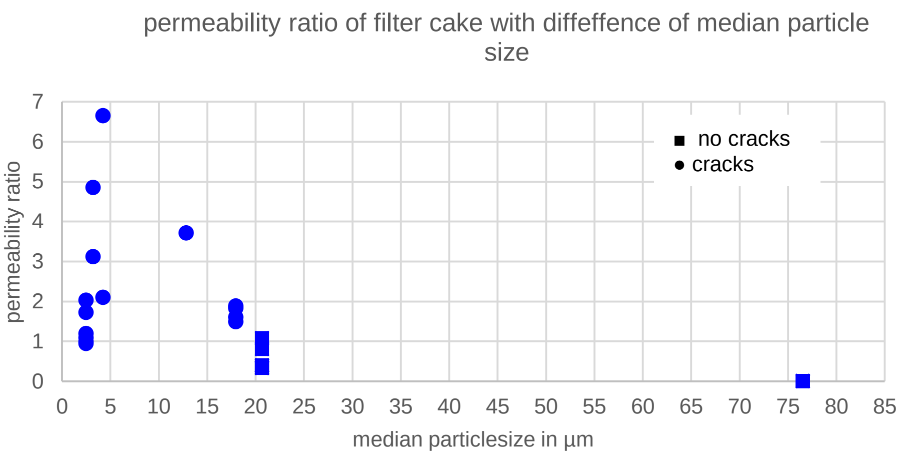
II. Experiment equipment and materials

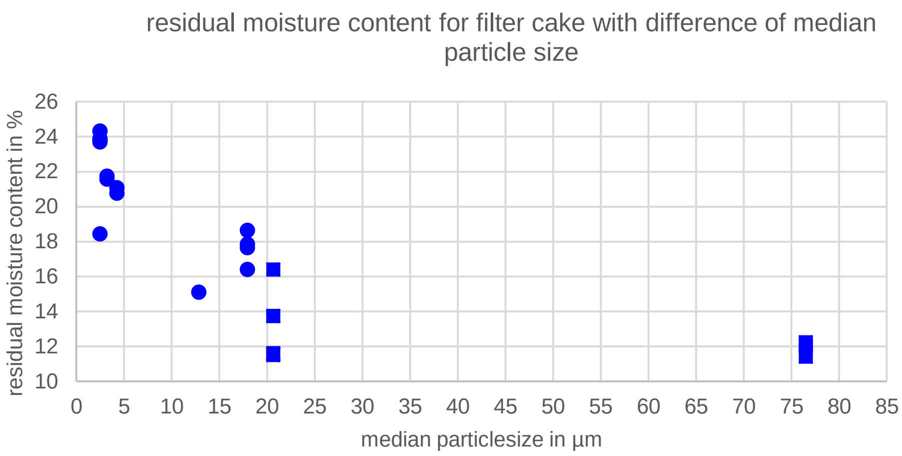


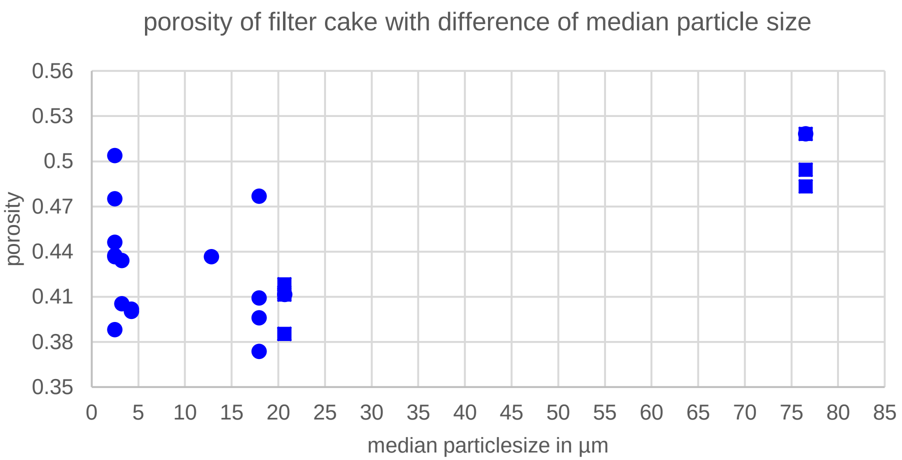
Dimesion of particles

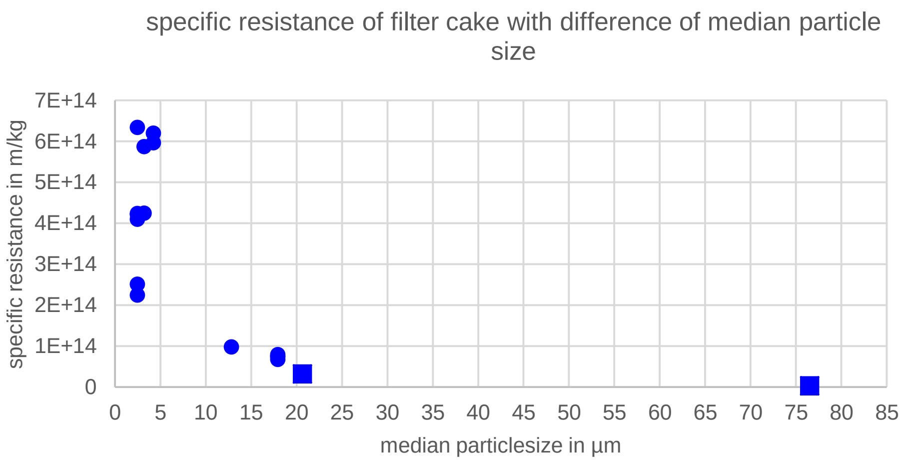
	x_{16}	x_{10}	x_{50}	Sauter parameter	x_{90}/x_{10}	$(x_{90}-x_{50})^2/(x_{50}-x_{10})^2$
KS < 12µm	0.93	0.71	2.46	1.60	11.34	10.20
KS <120µm	3.86	2.60	17.93	8.00	30.54	16.08
KS<100 µm	3.39	2.08	20.68	6.38	39.61	11.00
KS > 63 µm	49.83	27.49	76.53	24.00	4.00	0.46
KS < 100 µm after 2 minutes grinding	1.44	2.27	12.83	4.35	38.35	13.85
KS < 100 µm after 10 minutes grinding	0.86	1.17	4.24	2.14	19.38	13.52
KS < 100 µm after 35 minutes grinding	0.75	1	3.21	3.29	18.09	17.74

The effect of particle size on crack formation



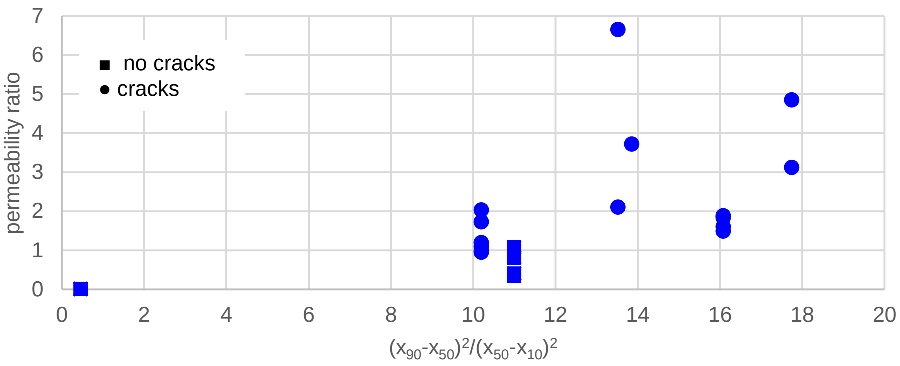




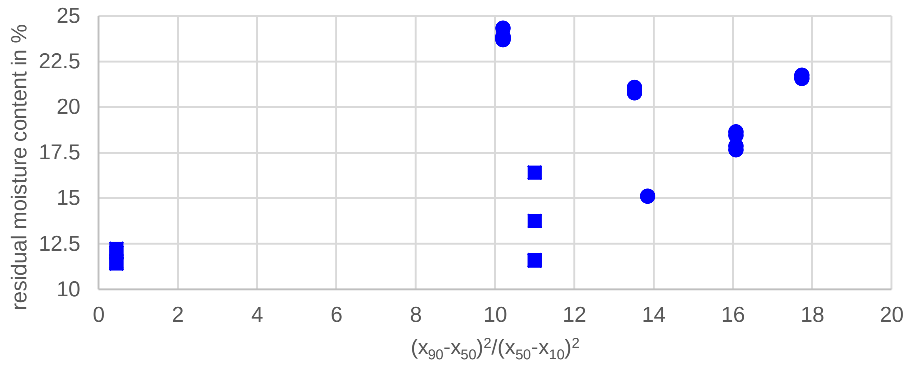


The effect of particle size distribution on crack formation

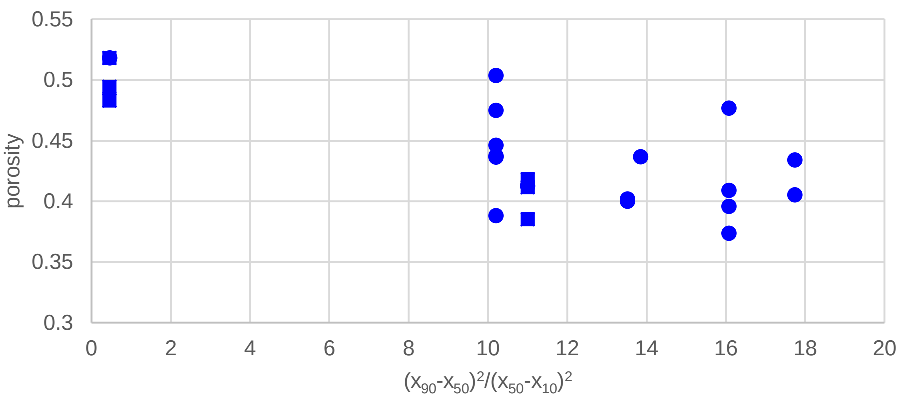
permeability ratio of filter cake with different particle size distribution



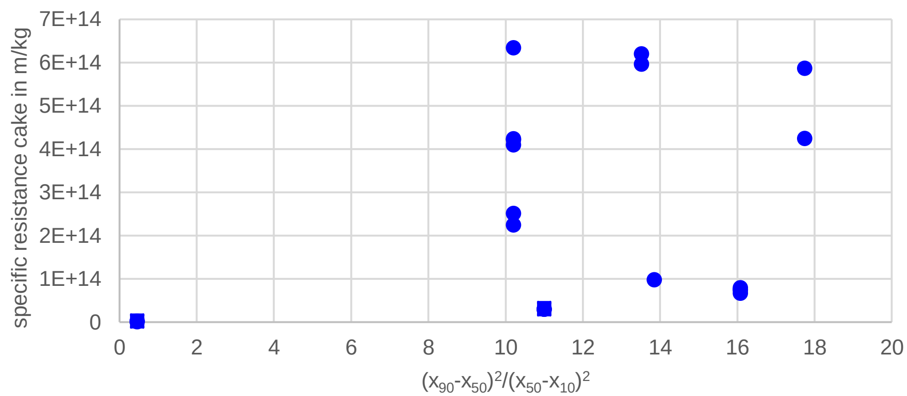
residual moisture content for filter cake with different particle size distribution



porosity of filter cake with different particle size distribution

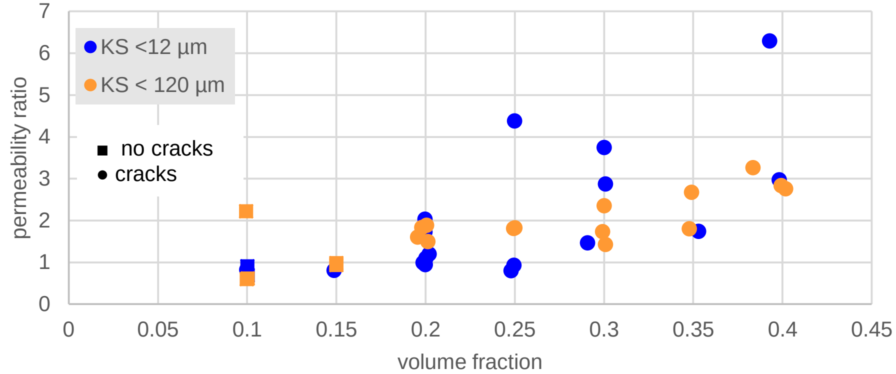


specific resistance of filter cake with different particle size distribution

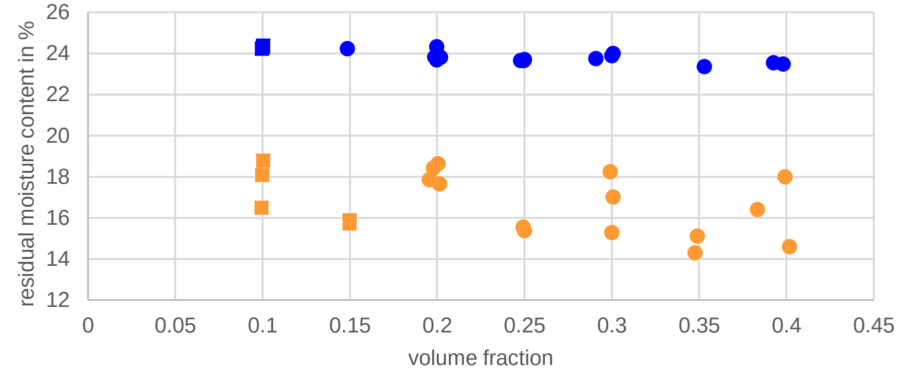


The effect of slurry concentration on cracks formation

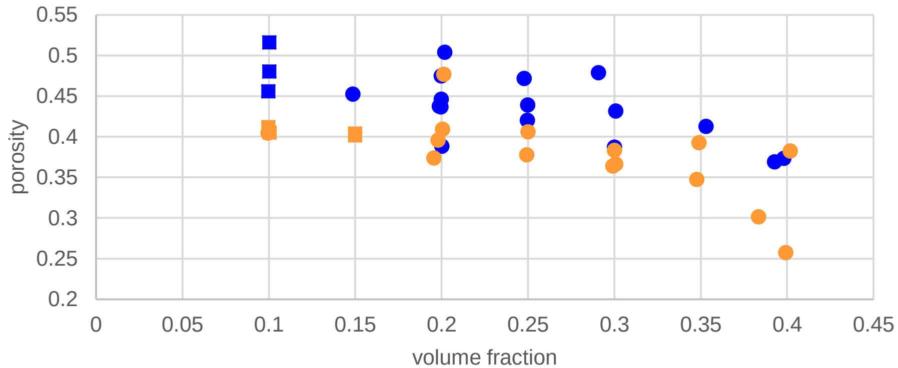
permeability ratio for filter cake KS< 12 µm and KS <120 µm with different volume fraction



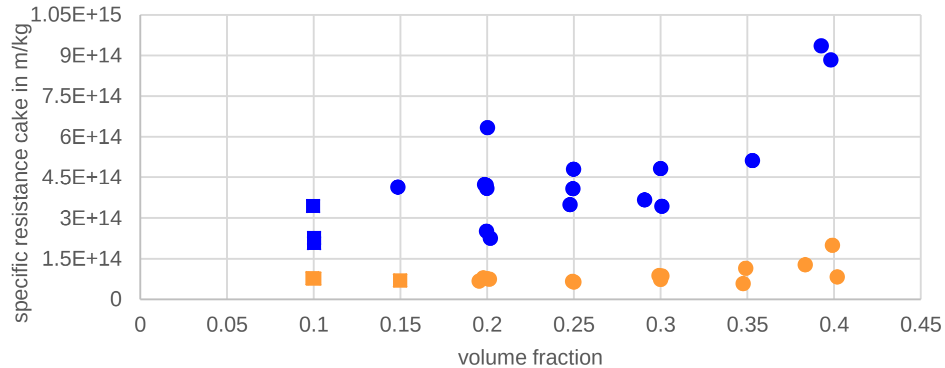
residual moisture content for filter cake KS< 12 µm and KS <120 µm with different volume fraction



porosity of filter cake KS< 12 µm and KS <120 µm with different volume fraction

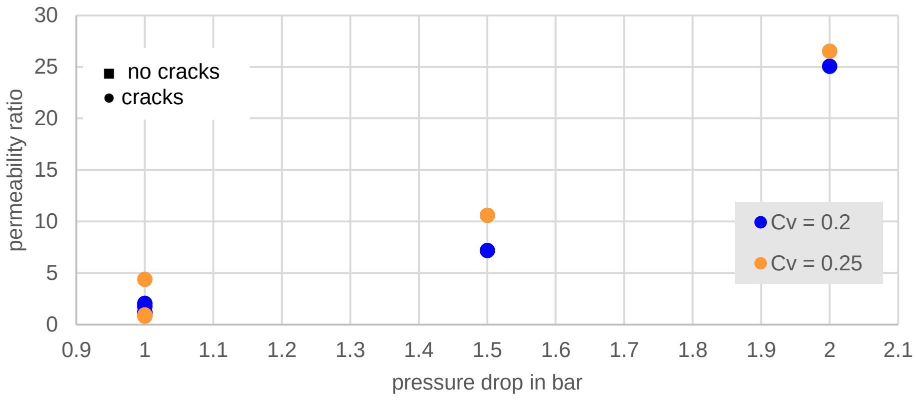


specific resistance cake of filter cake KS< 12 µm and KS <120 µm with different volume fraction

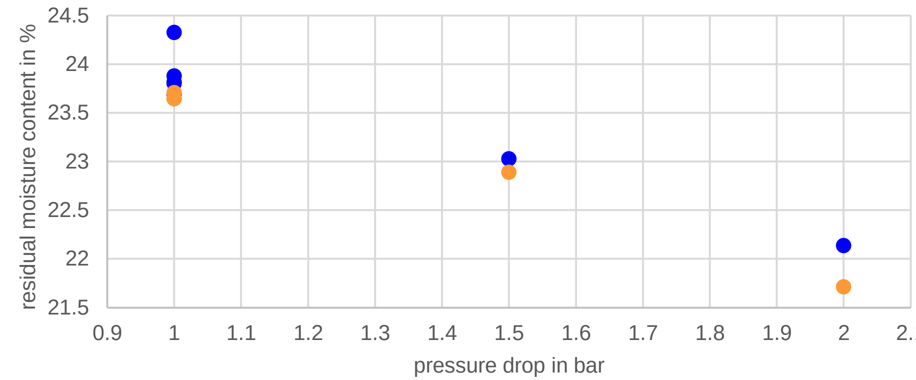


The effect of pressure drop on crack formation

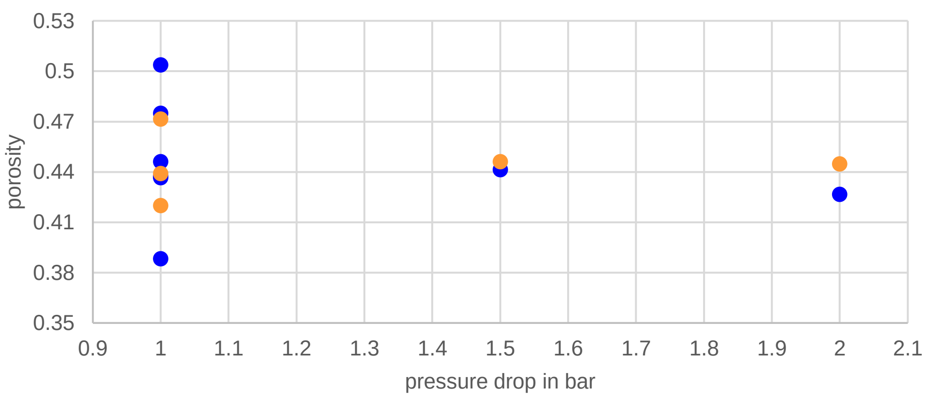
permeability ratio for filter cake KS < 12 µm with different pressure drop



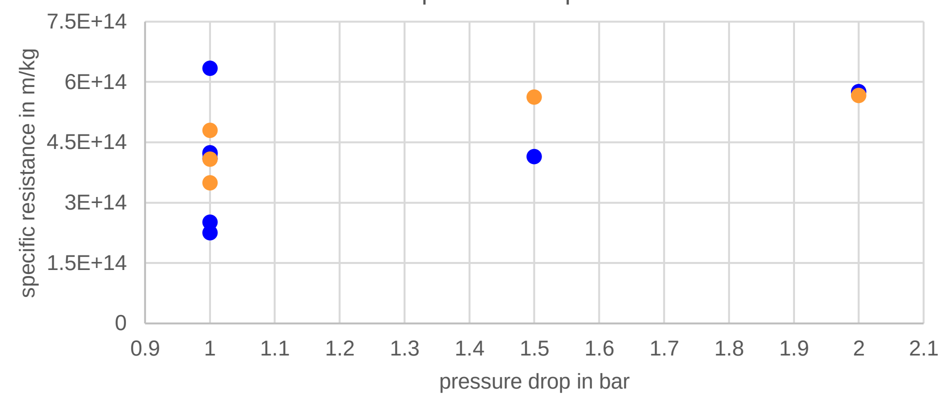
residual moisture content for filter cake KS <12 µm with different pressure drop



porosity of filter cake KS < 12 µm with different pressure drop

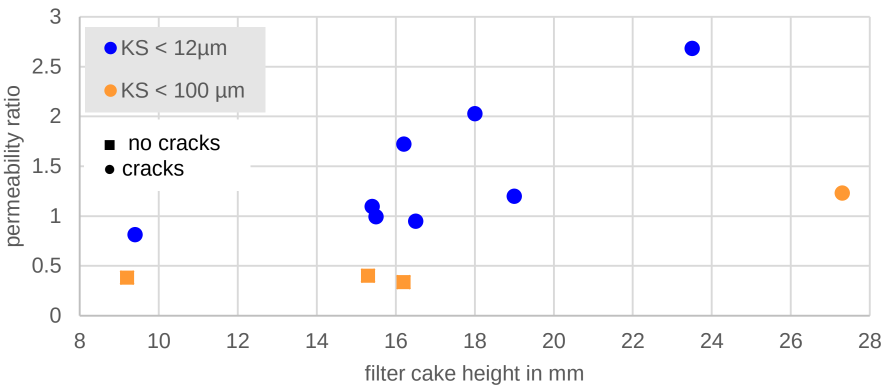


specific resistance of filter cake KS <12 µm with different pressure drop

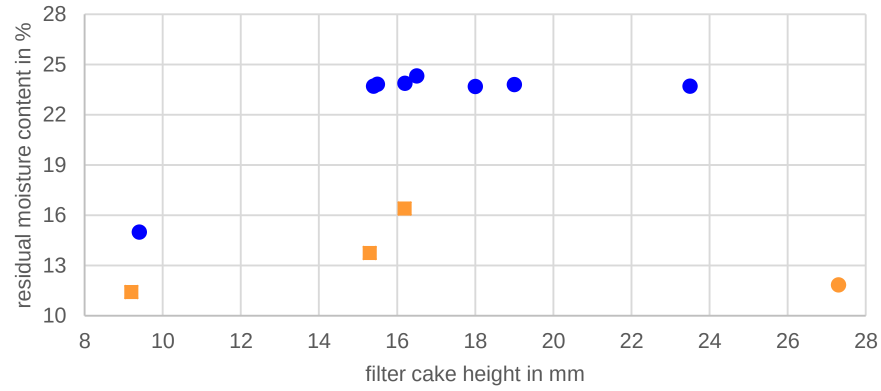


The effect of height of filter cake on crack formation

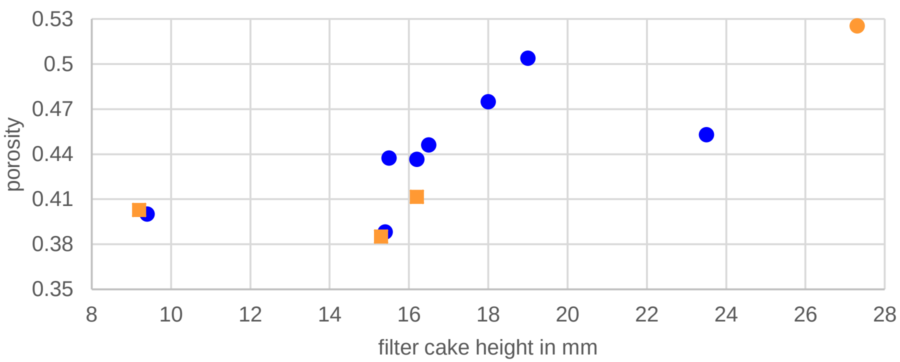
permeability ratio for filter cake KS < 12 µm and KS < 100 µm, Cv = 0.2 with different filter cake height



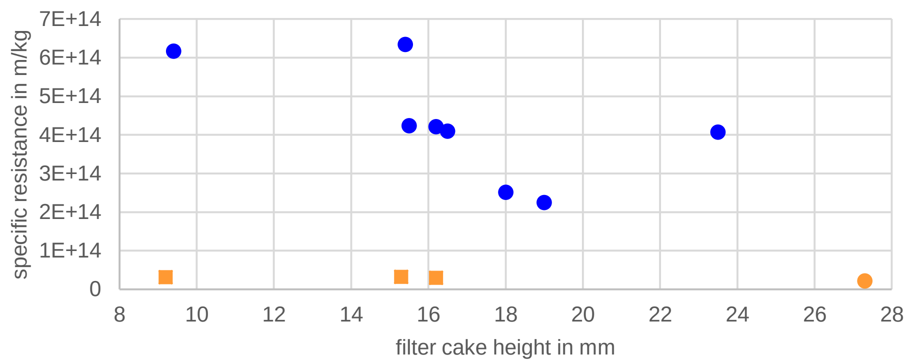
residual moisture content for filter cake KS < 12 µm and KS < 100 µm, Cv = 0.2 with different filter cake height



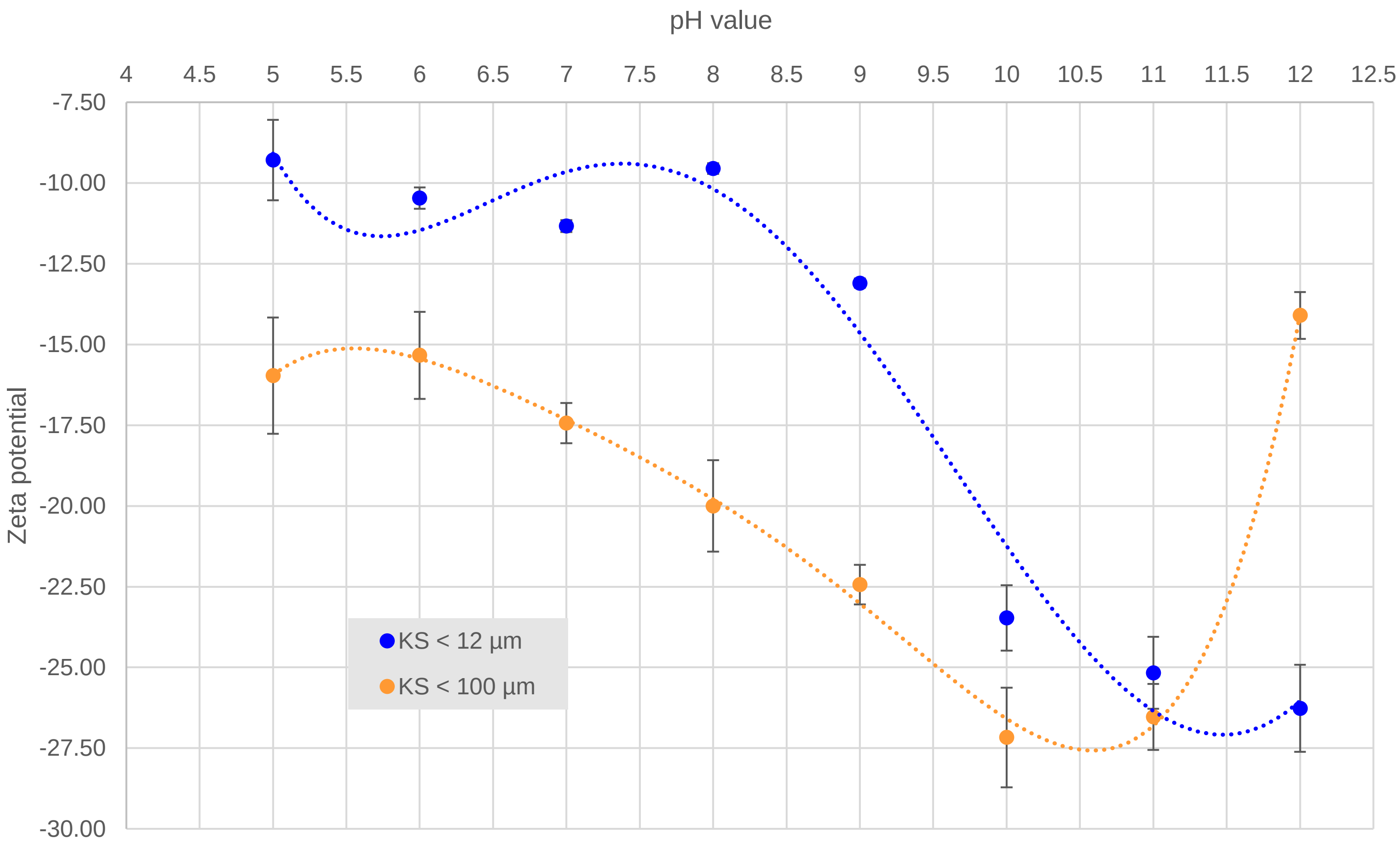
porosity of filter cake KS < 12 µm and KS < 100 µm, Cv = 0.2 with different filter cake height



specific resistance of filter cake KS < 12 µm and KS < 100 µm, Cv = 0.2 with different filter cake height



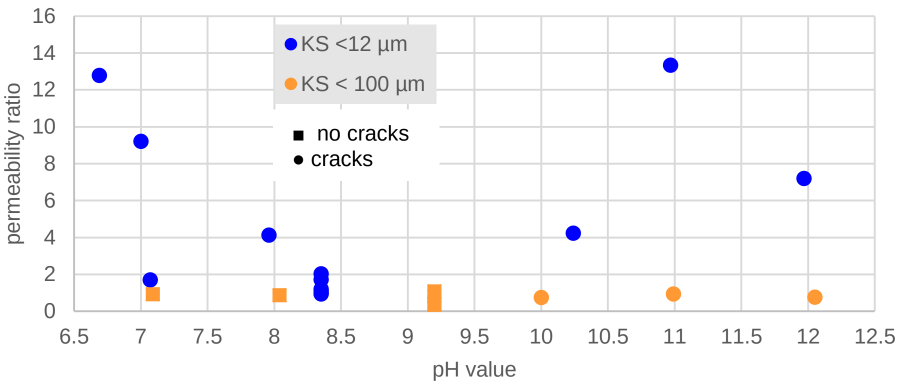
Zeta potential and the effect of pH on crack formation



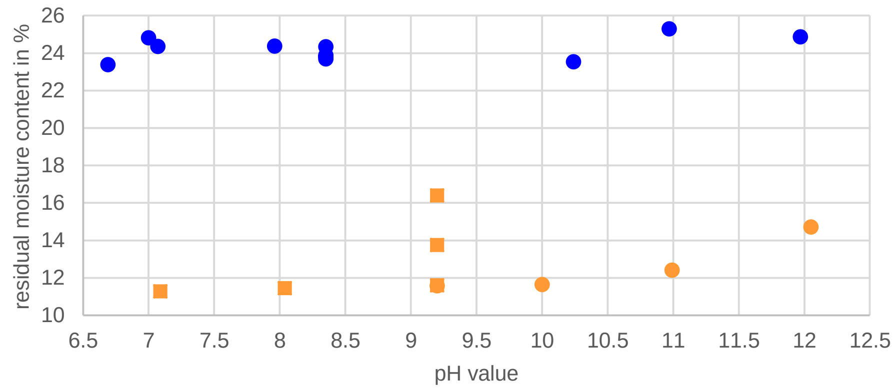
Zeta potential for KS < 12µm and KS < 100 µm

Zeta potential and the effect of pH on crack formation

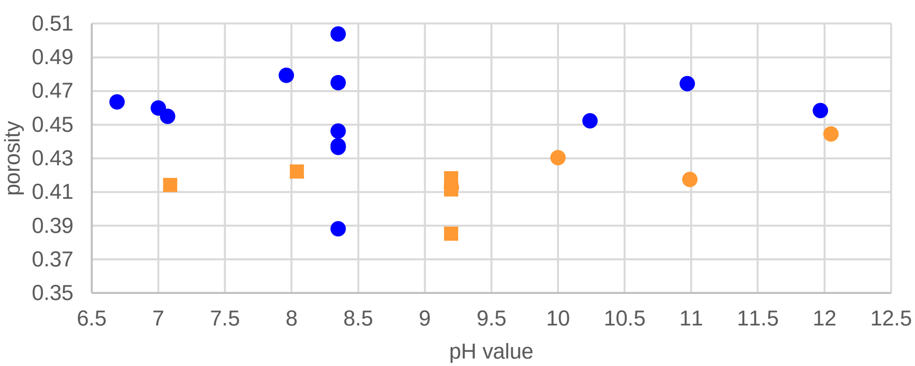
permeability ratio of filter cake KS < 12 µm and KS<100 µm, Cv = 0.2 with different pH value



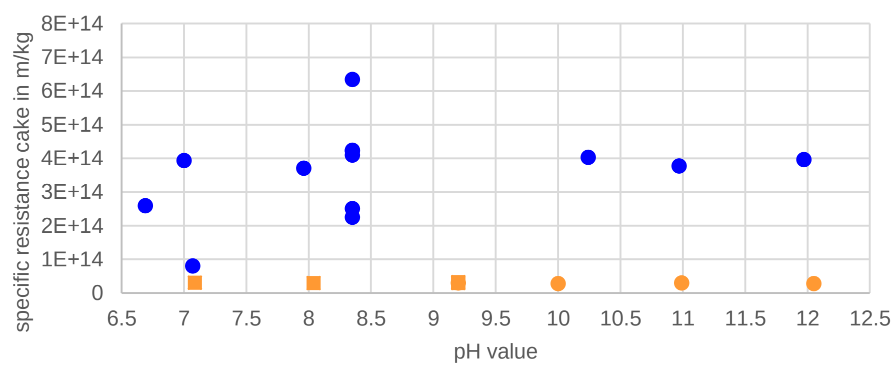
residual moisture content of filter cake KS < 12 µm and KS<100 µm, Cv = 0.2 with different pH value



porosity of filter cake KS < 12 µm and KS<100 µm, Cv = 0.2 with different pH value



specific resistance of filter cake KS < 12 µm and KS<100 µm, Cv = 0.2 with different pH value



6. Conclusion

- There are 3 kinds of forces affect on the adhesion between particles, however the capillary forces are the strongest force of all and capillary force is the essentially reason of crack formation on the filter cake
- Permeability ratio is a appropriate parameter to decribe and estimate degree of the crack on filter cake
- Both particle size distribution and particle size affect on the crack formation and the degree of crack on filter cake. The issue can be explain through the capillary force theory and the interaction between particles. The particle size distribution is suggested by the ratio **$(x_{90}-x_{50})^2/(x_{50}-x_{10})^2$,** the particle size is x_{50}
- Volume fraction of suspension also affect to the crack formation. With different of concentration of slurry, the filter cakes are built in different structure cake and change capillary forces between particles. The diferent of slurry concentration should be researched with the size of particle.

- The crack of filter cake is formed because of the structure of filter cake and the interaction between particles, however when the crack is formed, the higher pressure drop make higher degree of crack.
- With small particle size, the height of filter cake increase lead to the great amount of crack on filter cake. This phenomenon seem not true with the coarse particles and the low ratio $(x_{90}-x_{50})^2/(x_{50}-x_{10})^2$
- There is a different permeability ratio when the pH value change in KS < 12 µm but these value fluctuate, unfollowed one direction. May be there is another force affect on particles beside capillary force. With coarse particles, although the pH value is changed, permeability still nealy stable

Thank you for your attention!

Danke für Ihre Aufmerksamkeit!