Cascading Column System: Closing the Mass Balances and Results for Different Particles

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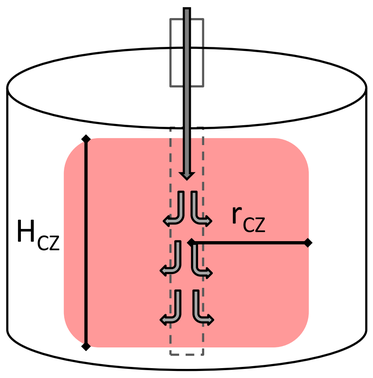
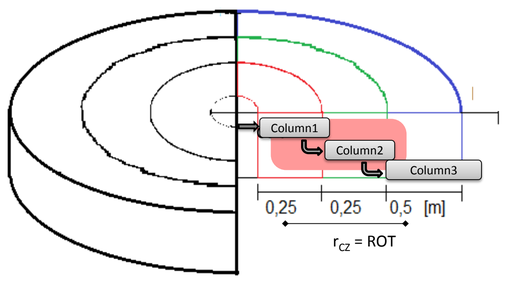
Motivation

- Comparison of migration and sedimentation properties of NANOFER 25S, NANOFER 25P and NANOFER STAR (NANO IRON s.r.o.)
- Control accordance of different results for nZVI mass $M_{Fe(0)}$ and transport length Δx from susceptibility measurement system, mass balance and lab
- Recommendation on particle type and injection condition for up-scaled end user application

Goal

To ensure transferability of results to field situations parameters used in Cascading Column System base on realistic field injections.





Field

Initial Parameter:
- H_{CZ}, r_{CZ}, $K_{aquifer}$ (μ, p)
- C_{CZ} → $C_{Fe(0)}$
- C_{CMC}
- μ(C_{CMC} , $C_{Fe(0)}$)

=> **Q (Aquifer, Pump)**

Cascading Column System

Radius of Transport (ROT) = $\mathbf{r_{CZ}}$

$$v = \frac{Q}{2*\pi*H_{CZ}*r_{CZ}*n}$$

$$v\ (Column\ i) = \frac{2}{\frac{1}{v(\text{column i}),1} + \frac{1}{v(\text{column i}),2}}$$

$$Q(SColumn\ i) = v\ (Column\ i)\ *\ A\ (Column\ i) * n$$

YES

ROT achieved?

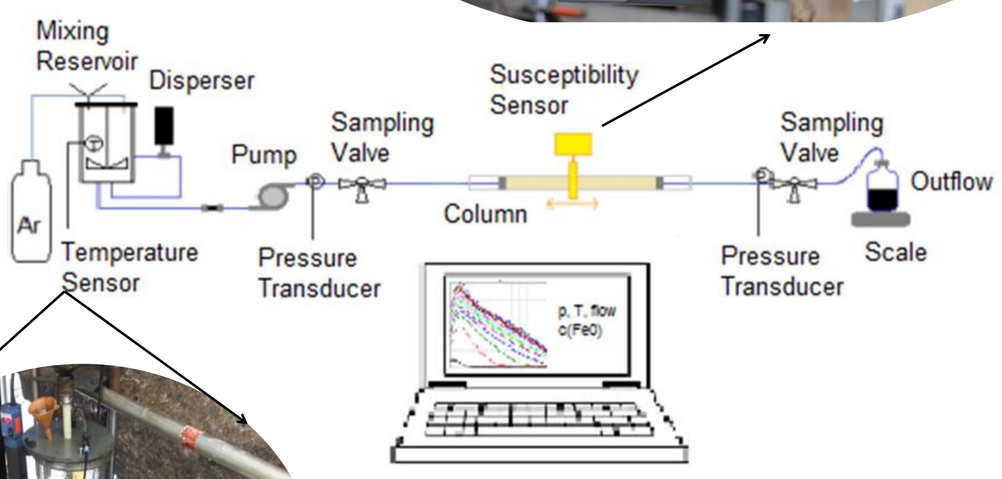
NO

Field application

Modifications:
1. C_{CMC} , $C_{Fe(0)}$
2. Increase volume or duration of injection
3. Decrease filter lenght to $H_{CZ}\ /\ x \rightarrow Q_{neu} = Q * x$

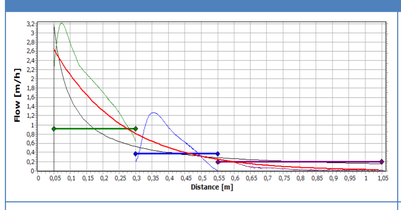
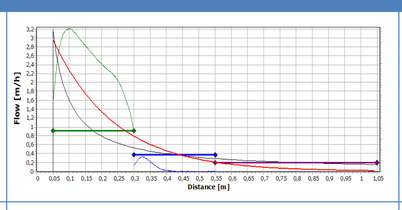
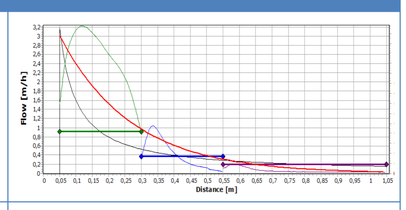
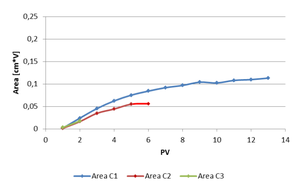
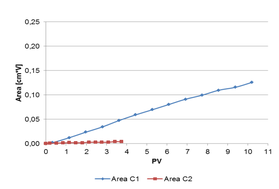
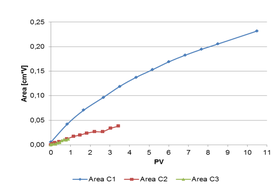
→ repeat injection on i level

Set-up



Flow chart of Cascading Column Set-up

Comparison of Nanofer 25S, 25P and Star

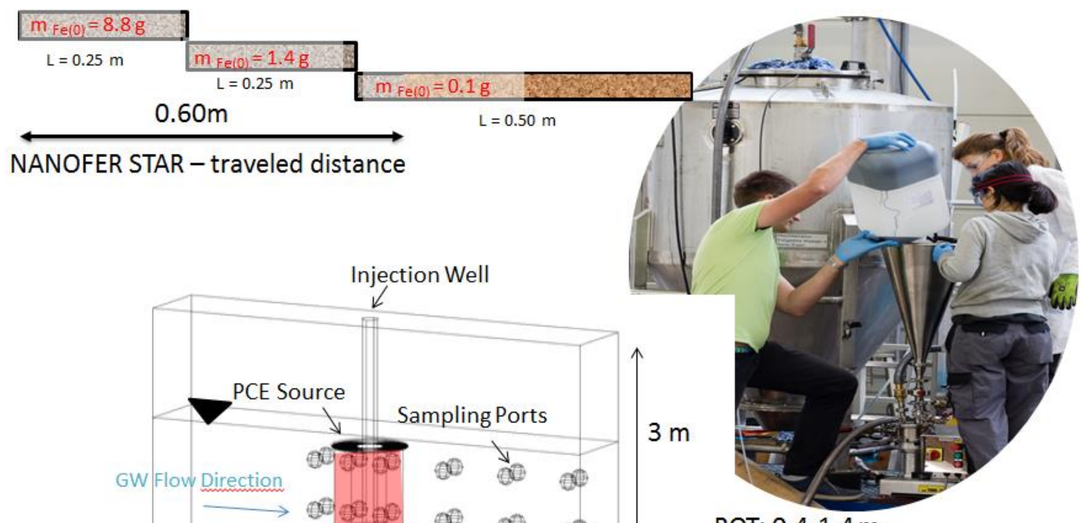
NANOFER 25S	NANOFER 25P	NANOFER STAR
		
		
Δx: 0.58 m	Δx: 0.37 m	Δx: 0.60 m
		

➔ Almost all nZVI of 25P particle deposited in first 0.25m
➔ Migration and sedimentation of sufficient quantity of nZVI for 25S and STAR particle
➔ Due to easier handling (powder) and no additional stabilizer, NANOFER STAR particles are recommended for next injections

Comparison of Nanofer 25S and Nanofer Star

Set	Area [cm*V]	$M_{Fe(0)}$ [g]	Δx [m]	$M_{Fe(0)}$ [g]			$M_{Fe(0)}$ [g]	Δx [m]
	Susceptibility Measurement System			Mass Balance 1	Mass Balance 2	Mass Balance 3	Mass Balance 4	Lab Results	
NANOFER 25S									
XI C1	0.113			5.40	4.53	4.72		7.13	
XI C2	0.056			2.67	2.24	2.34		-	0.58
XI C3	0.018			0.86	0.72	0.75		-	
NANOFER STAR									
XI C1	0.232						7.01	8.75	
XI C2	0.038						1.15	1.44	0.60
XI C3	0.012						0.36	0.10	

Optimal Conditions for Application Group



ROT: 0,4-1,4 m
mFe^0: 10 kg

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